MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS, ABSTRACTS OF PAPERS, AND

REPORTS OF THE PROCEEDINGS

OF THE SOCIETY

FROM NOVEMBER 1895 *TO NOVEMBER* 1896.

VOL. LVI.

LONDON:
ROYAL ASTRONOMICAL SOCIETY,
BURLINGTON HOUSE, W.
1896.

PRINTED BY
SPOTTISWOODE AND CO., NEW-STREET SQUARE
LONDON

BIBL.
LONDIN.
UNIV.

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LVI. NOVEMBER 8, 1895. No. 1

A. A. COMMON, LL.D., F.R.S., President, in the Chair.

Antoine d'Abbadie, Membre de l'Institut des Sciences, Abbadia, Hendaye (Basses-Pyrenées), France ;
Loyal H. Bradford, North Ferrisburgh, Vermont, U.S.A. ;
Oswald Thomas Tuck, School Ship *Conway*, Birkenhead,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Hugh Lancelot Aldis, Secretary of Public Company, 67 Dieppe Street, West Kensington, W. (proposed by E. J. Spitta) ;
William Ernest Cooke, M.A., First Assistant Astronomer, Adelaide Observatory (proposed by Sir C. Todd) ;
Alpin G. Fowler, M. Inst. C.E., Civil Engineer, 1 Cambridge Road, Norbiton (proposed by W. H. M. Christie) ;
David Edward Hadden, Alta, Buena Vista Co., Iowa, U.S.A. (proposed by L. A. Eddie) ;
The Rev. Robert Killip, Sale, Manchester (proposed by Sir R. S. Ball) ;
George Handley Knibbs, Lecturer in Surveying, University, Sydney, New South Wales, Australia (proposed by R. T. A. Innes) ;
Frederick William McCarthy, Practical Astronomer, 20 Chepstow Place, Bayswater, W. (proposed by J. McCarthy) ;
Charles J. Merfield, Department of Public Works, Sydney, New South Wales, Australia (proposed by R. T. A. Innes) ;
Hugh Griffith Quirk, Master Mariner, Baymount, Vico Road, Dalkey, co. Dublin (proposed by S. M. Yeates).

One hundred and ninety-five presents were announced as having been received since the last meeting, including, amongst others :—

American Nautical Almanac Papers (Newcomb, Tables of the Sun and *Mercury* ; Hill, Tables of *Jupiter* and *Saturn*), presented by the American Nautical Almanac Office ; Aratus, Astronomy and Meteorology, translation of, presented by C. L. Prince ; Sir R. S. Ball, Great Astronomers, presented by the publishers ; J. Bossert, Catalogue des mouvements propres d'étoiles, presented by the author ; Cape Catalogue of 1,713 Stars, presented by the Observatory ; A. Cayley, Collected Mathematical Papers, vol. viii., presented by the author ; Cincinnati Observatory Publications, No. 13 (Porter, catalogue of 2,000 stars), presented by the Observatory ; A. M. Clerke, The Herschels and Modern Astronomy, presented by the author; Greenwich Observations, &c., 1892, presented by the Royal Observatory ; Nice Observatoire, Annales, tomes iv., v., presented by M. Bischoffsheim ; J. A. C. Oudemans, Triangulation von Java, presented by Professor Oudemans ; W. F. Stanley, Notes on the Nebular Theory, presented by the author ; Photograph of part of Milky Way, presented by Dr. Sheldon ; Photographs of Hammerfest and Vadsö, presented by T. R. Clapham.

Reproduction of Astronomical Photographs.

In continuation of the note in the June number of the *Monthly Notices*, a further list of photographs now on sale to Fellows is given below.

Lantern slides can now also be obtained of any of these, and of those included in the former list.

Price of prints, 1*s.* 6*d.* each ; slides, 1*s.* each. In ordering prints please state whether platinotype or aristotype are required. The R.A.S. reference number need only be quoted : orders to be addressed to W. H. Wesley.

R.A.S. Reference No.	Subject.	Photograph by
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	MM. Lœwy and Puiseux

---

Note on the Value of the Longitude in the Lunar Theory when the Sun's Mass is put Zero. By P. H. Cowell, B.A., Fellow of Trinity College, and Isaac Newton, Student in the University of Cambridge.

(*Communicated by F. W. Dyson, M.A.*)

About fifteen years ago a paper was published in Silliman's journal* by Mr. Stockwell, in which he called attention to the fact that when the mass of the Sun, and therefore its mean motion, is put equal to zero, Delaunay's expression for the longitude† does not degenerate into the ordinary formula for elliptic motion, but contains terms in which the Sun's eccentricity, and the position of the Sun's apse, and the ratio of the parallaxes enter. Mr. Stockwell argued that there must therefore be "something seriously wrong" with Delaunay's analysis.

Mr. Stockwell's objection has been discussed by M. Gogou.‡ He has shown that when the Sun's mass is zero, and consequently when the Moon's node and apse are fixed, certain operations of Delaunay's may be modified. Some terms with different arguments coalesce, and the accuracy of Delaunay's results is fully established, so far as the terms objected to by Mr. Stockwell are concerned.

M. Gogou's work, which involves a modification of several of Delaunay's operations, is very long and laborious. Moreover it merely verifies Delaunay's terms without explaining the physical (in contradistinction to the analytical) reason why such terms should exist. In this paper the question is treated from a different standpoint; the mean motion of the Sun, instead of being put zero, is made to diminish without limit.

At the beginning of his analysis Delaunay replaced the mass of the Sun m' by $n'^2a'^3$ (his notation is well known, and it is unnecessary to explain the meaning of the symbols that occur in this paper); whereas, more accurately, the relation is

$$\mu + m' = n'^2a'^3,$$

μ being the mass of the Earth. Delaunay's analysis is therefore founded upon the assumption that the Sun's mass is extremely large in comparison with the Earth's. Now, when we suppose n' to be diminished to a very small fraction of its actual value, we must either suppose a' increased or m' diminished. It is inconvenient to suppose a' increased, as it would diminish some of the terms in Delaunay's degenerate expression that we are about to consider, and an explanation of them as they stand is more

* *American Journal*, vol. xx. 3rd series, 1880.
† *Mémoires de l'Académie des Sciences*, vol. xxix. ch. xi.
‡ *Annales de l'Observatoire de Paris*, vol. xviii. 1885.

satisfactory. On the other hand, if m' is greatly diminished, the Earth's mass may not be neglected in comparison with it. Now Delaunay's final expression for the longitude has been calculated to the seventh order of small quantities. The quantities neglected, being of the eighth order, are comparable with 10^{-8} or 10^{-9}, whereas the ratio $\mu : m'$ is apparently 3×10^{-6}. Again, if E be the mass of the Earth, M the mass of the Moon, Delaunay neglects M/E. We know, however, that if we replace $1/a'$ by $(E-M)/(E+M)a'$ wherever it occurs in Delaunay's final expression, the parallactic terms that contain the first power of the ratio of the parallaxes are by this change rendered perfectly accurate, but the terms containing the square and higher powers of the ratio of the parallaxes are not rendered accurate in this manner, though the error is very small, and probably is comparable with 10^{-7}. A physical interpretation must be given to the simplifications (such as neglecting μ/m') introduced by Delaunay, and then his results become the solution, accurate to the seventh order, of a definite problem, different—but not very different—from the problem actually presented by the Moon.

We are led, therefore, to examine what physical problem Delaunay has actually solved.

In the problem of two bodies, the Earth and Sun, suppose we have the relation

$$\mu + m' = n'^2 a'^3.$$

If, however, one of the two bodies be supposed fixed (in the same sense that the centre of gravity of two or more free bodies may be supposed fixed), we may conceive that one body attracts the other, but is not attracted by it, or else that external forces are called into play, neutralising the attraction of the second body upon the first ; the relation then becomes

$$m' = n'^2 a'^3,$$

which is that used by Delaunay. Delaunay, therefore, solves the following problem—to investigate the motion, supposed nearly circular, of a Moon of no mass under the attraction of the Earth and disturbed by a distant Sun, which produces acceleration in both the Earth and Moon according to Newton's law, but which is not itself affected by attractions from them.

This is a definite problem, and one that reduces to elliptic motion when the Sun's mass vanishes. Moreover, when the Sun's mass is large the error in supposing the Sun at rest instead of the centre of gravity at rest is not large, although larger than some of the terms given by Delaunay. When the Sun's mass is small the problem ceases to have any resemblance to that of three free bodies.

Let us suppose the Sun's mass so small that n'/n is of the seventh order of small quantities. Then no periodic term in the

solution due to the action of the Sun is of a lower order than the eighth, and the motion must therefore be sensibly elliptic. However, the node and apse move continually in one direction, although with extreme slowness, so that after the lapse of a long time the ellipse described is a distinctly different one. Analysis also shows that the eccentricity and inclination undergo finite variations (that is to say, variations that do not become insensible when m is insensible). The eccentricity and inclination at any instant turn out to be functions of the configuration of the node and apses, and are therefore only constant when the configuration remains unchanged, that is to say, when m' and n' are absolutely zero.

The explanation of the terms discussed by Mr. Stockwell and M. Gogou, therefore, is that, when terms containing m are neglected, Delaunay's expressions must represent, not merely elliptic motion in one definite and fixed ellipse, but must be capable of representing motion in any one of that doubly infinite variety of ellipses, with which the sensible motion coincides, when any arbitrary values are given to the longitudes of apse and node.

It remains to verify the foregoing explanation by showing that by formulæ of transformation that involve the configuration of node and apses only Delaunay's degenerate expressions can be identified with the expressions for elliptic motion. Assuming, therefore, the identity of Delaunay's degenerate expression for the longitude with the expression in purely elliptic motion for all values of the time, we may separately equate those terms whose speed is the same multiple of the mean motion. We shall therefore obtain the relations we seek from the terms in the longitude whose speed is the mean motion or twice the mean motion, and we shall verify the algebraic work by a comparison of those terms whose speed is three times the mean motion. This verification will also constitute a sufficient guarantee of the accuracy of the foregoing explanation as to the reasons why the terms under discussion appear. It appears scarcely necessary to perform the corresponding algebraic work for the terms in the latitude and parallax and the terms of shorter period in the longitude.

We give below those terms in Delaunay's expression for the longitude that are independent of m, and whose speed is once, twice, or thrice the mean motion. We restore Delaunay's notation of l, g, h, g', h' (in chapter xi. he has used the symbols D, F, l), and we write χ for $h+g-h'-g'$, the distance between the apses, and we notice that there are no terms containing l'. This last fact is a confirmation of the theory, because there are no terms of corresponding speed in the purely elliptic expression. The expression referred to is

$$\left(2e-\frac{1}{4}e^3+\frac{5}{96}e^5\right)\sin l$$

$$+\left(-3\gamma^2e-18\gamma^4e+\frac{61}{8}\gamma^2e^3-\frac{447}{4}\gamma^6e+92\gamma^4e^3-\frac{925}{96}\gamma^2e^5-\frac{165}{16}\gamma^2e\frac{a^2}{a'^2}\right)\sin(2g+l)$$

$$+\left(\frac{7}{6}\gamma^2e^3+\frac{359}{12}\gamma^4e^3-\frac{285}{64}\gamma^2e^5\right)\sin(2g-l)$$

$$+\frac{11}{24}\gamma^4e^3\sin(4g+l)$$

$$+\frac{165}{64}ee'^2\frac{a^2}{a'^2}\sin(2\chi+l)$$

$$+\left(\frac{5}{2}e'-\frac{15}{2}\gamma^2e'+\frac{15}{2}e^2e'+\frac{5}{2}e'^3+\frac{15}{2}\gamma^4e'-\frac{55}{2}\gamma^2e^2e'+\frac{465}{128}e^4e'\right)\frac{a}{a'}\sin(\chi+l)$$

$$+\left(\frac{105}{16}e^2e'-\frac{365}{16}\gamma^2e^2e'+\frac{385}{96}e^4e'\right)\frac{a}{a'}\sin(\chi-l)$$

$$+\frac{205}{16}\gamma^2e^2e'\frac{a}{a'}\sin(\chi+2g+l)$$

$$+\left(\frac{5}{6}\gamma^2e'+\frac{5}{3}\gamma^4e'+\frac{145}{48}\gamma^2e^2e'\right)\frac{a}{a'}\sin(\chi-2g-l)-\frac{115}{144}\gamma^2e^2e'\frac{a}{a'}\sin(\chi-2g+l)$$

$$+\left(\frac{5}{4}e^2-\frac{5}{4}\gamma^2e^2-\frac{11}{24}e^4-\frac{85}{8}\gamma^4e^2+\frac{35}{16}\gamma^2e^4+\frac{17}{192}e^6\right)\sin 2l$$

$$+\left(-\gamma^2-\gamma^4-\frac{9}{4}\gamma^2e^2-\gamma^6-\frac{89}{4}\gamma^4e^2+\frac{165}{16}\gamma^2e^4\right)\sin(2g+2l)$$

$$+\frac{99}{64}\gamma^2e^4\sin(2g-2l)+\frac{39}{16}\gamma^4e^2\sin(4g+2l)$$

$$+\frac{125}{64}e'^2\frac{a^2}{a'^2}\sin(2\chi+2l)+\left(\frac{25}{8}ee'-\frac{265}{24}\gamma^2ee'+\frac{135}{16}e^3e'+\frac{25}{8}ee'^3\right)\frac{a}{a'}\sin(\chi+2l)$$

$$+\frac{805}{96}e^3e'\frac{a}{a'}\sin(\chi-2l)-\frac{75}{16}\gamma^2ee'\frac{a}{a'}\sin(\chi+2g+2l)-\frac{35}{24}\gamma^2ee'\frac{a}{a'}\sin(\chi-2g-2l)$$

$$+\left(\frac{13}{12}e^3-\frac{5}{2}\gamma^2e^3-\frac{43}{64}e^5-\frac{165}{8}\gamma^4e^3+5\gamma^2e^5\right)\sin 3l$$

$$+\left(-2\gamma^2e-2\gamma^4e-\frac{11}{8}\gamma^2e^3-2\gamma^6e-\frac{49}{2}\gamma^4e^3+\frac{881}{64}\gamma^2e^5\right)\sin(2g+3l)$$

$$+\frac{1357}{640}\gamma^2e^5\sin(2g-3l)$$

$$+\left(3\gamma^4e+21\gamma^6e-\frac{105}{16}\gamma^4e^3\right)\sin(4g+3l)$$

$$+\frac{325}{64}ee'^2\frac{a^2}{a'^2}\sin(2\chi+3l)$$

$$+\left(\frac{65}{16}e^2e'-\frac{895}{48}\gamma^2e^2e'+\frac{315}{32}e^4e'\right)\frac{a}{a'}\sin(\chi+3l)$$

$$+\frac{2815}{256}e^4e'\frac{a}{a'}\sin(\chi-3l)$$

$$+\left(-\frac{5}{2}\gamma^2e'+5\gamma^4e'-\frac{245}{16}\gamma^2e^2e'\right)\frac{a}{a'}\sin(\chi+2g+3l)-\frac{505}{48}\gamma^2e^2e'\frac{a}{a'}$$
$$\sin(\chi-2g-3l)-\frac{5}{6}\gamma^4e'\frac{a}{a'}\sin(\chi-4g-3l).$$

The expression in purely elliptic motion is

$$\left(2e_0-\frac{1}{4}e_0^3+\frac{5}{96}e_0^5\right)\sin l_0+\left(2\gamma_0^2e_0+2\gamma_0^4e_0-\frac{7}{4}\gamma_0^2e_0^3+2\gamma_0^6e_0\right.$$
$$\left.-\frac{7}{4}\gamma_0^4e_0^3+\frac{5}{96}\gamma_0^2e_0^5\right)\sin(2g_0+l_0)$$
$$+\left(-\frac{1}{12}\gamma_0^2e_0^3-\frac{1}{12}\gamma_0^4e_0^3-\frac{5}{192}\gamma_0^2e_0^5\right)\sin(2g_0-l_0)-\frac{17}{12}\gamma_0^4e_0^3\sin(4g_0+l_0)$$
$$+\left(\frac{5}{4}e_0^2-\frac{11}{24}e_0^4+\frac{17}{192}e_0^6\right)\sin 2l_0+\left(-\gamma_0^2-\gamma_0^4+4\gamma_0^2e_0^2-\gamma_0^6+4\gamma_0^4e_0^2\right.$$
$$\left.-\frac{55}{16}\gamma_0^2e_0^4\right)\sin(2g_0+2l_0)-\frac{1}{24}\gamma_0^2e_0^4\sin(2g_0-2l_0)+\frac{11}{4}\gamma_0^4e_0^2$$
$$\sin(4g_0+2l_0)$$
$$+\left(\frac{13}{12}e_0^3-\frac{43}{64}e_0^5\right)\sin 3l_0+\left(-2\gamma_0^2e_0-2\gamma_0^4e_0+\frac{27}{4}\gamma_0^2e_0^3-2\gamma_0^6e_0+\frac{27}{4}\gamma_0^4e_0^3\right.$$
$$\left.-\frac{207}{32}\gamma_0^2e_0^5\right)\sin(2g_0+3l_0)-\frac{9}{320}\gamma_0^2e_0^5\sin(2g_0-3l_0)+\left(-2\gamma_0^4e_0\right.$$
$$\left.-4\gamma_0^6e_0+\frac{45}{4}\gamma_0^4e_0^3\right)\sin(4g_0+3l_0).$$

where only the terms of the same speed as before are retained. A suffix zero has been placed after e_0, γ_0, g_0, l_0 in this expression, $l-l_0$ is constant and small, but there is no reason why it should be zero.

Beginning with the terms whose speed is the mean motion and retaining terms of the third order only, we get

$$\left(2e-\frac{1}{4}e^3\right)\sin l-3\gamma^2e\sin(2g+l)+\frac{5}{2}e'\frac{a}{a'}\sin(\chi+$$
$$=\left(2e_0-\frac{1}{4}e_0^3\right)\sin l_0+2\gamma_0^2e_0\sin(2g_0+l$$

As a first approximation

$$e\sin l=e_0\sin l_0.$$

In time $\pi/2n$, we have

$$e\sin(l+\pi/2)=e_0\sin(l_0+\pi/2)$$

or

$$e\cos l=e_0\cos l_0.$$

As a general rule we may in any equation change sines into cosines, changing the sign of the coefficient, however, when the coefficient of l or l_0 is negative.

On referring to the equation obtained by equating terms containing $2l$, $2l_0$, we find that we commit an error of the fourth order in replacing

$$\gamma_0^2 \sin(2g_0 + 2l_0)$$

by

$$\gamma^2 \sin(2g + 2l)$$

It follows that $e_0 - e$, $\gamma_0^2 - \gamma^2$, $l_0 - l$, $g_0 - g$, are respectively of the third, fourth, second and second orders, and hence in any equation we may drop the suffixes in the terms of the highest order retained.

We therefore at once obtain as a second approximation

$$e_0 \sin l_0 = e \sin l - \frac{5}{2}\gamma^2 e \sin(2g + l) + \frac{5}{4} e' \frac{a}{a'} \sin(\chi + l) \quad . \quad . \quad . \quad (1)$$

Again, from the terms whose speed is equal to twice the mean motion, we get correctly to the fourth order.

$$\left(\frac{5}{4}e^2 - \frac{5}{4}\gamma^2 e^2 - \frac{11}{24}e^4\right) \sin 2l + \left(-\gamma^2 - \gamma^4 - \frac{9}{4}\gamma^2 e^2\right) \sin(2g + 2l)$$

$$+ \frac{25}{8} e e' \frac{a}{a'} \sin(\chi + l) = \left(\frac{5}{4}e_0^2 - \frac{11}{24}e_0^4\right) \sin 2l_0 + (-\gamma_0^2 - \gamma_0^4 + 4\gamma_0^2 e_0^2)$$
$$\sin(2g_0 + 2l_0)$$

We deduce from (1) and the corresponding formula where cosines replace sines,

$$e_0^2 \sin 2l_0 = e^2 \sin 2l - 5\gamma^2 e^2 \sin(2g + 2l) + \frac{5}{2} e e' \frac{a}{a'} \sin(\chi + 2l)$$

Whence

$$\gamma_0^2 \sin(2g_0 + 2l_0) = \gamma^2 \sin(2g + 2l) + \frac{5}{4}\gamma^2 e^2 \sin 2l \quad . \quad . \quad . \quad (2)$$

From (1) we deduce

$$e_0^2 = e^2 - 5\gamma^2 e^2 \cos 2g + \frac{5}{2} e e' \frac{a}{a'} \cos \chi$$

and from (2),

$$\gamma_0^2 = \gamma^2 + \frac{5}{4}\gamma^2 e^2 \cos 2g$$

We must now return to the first equation and retain the terms of the fifth order, and approximate to the terms of the third order as far as the fifth order, by means of the results already obtained. We then return to the second equation and approximate as far as the sixth order. We thus obtain,

$$e_0 \sin l_0 = e \sin l - \frac{5}{2}\gamma^2 e \sin(2g + l)$$

$$+\frac{5}{4}e'\frac{a}{a'}\sin(\chi+l)$$

$$+\left(\frac{5}{2}\gamma^4 e-\frac{5}{4}\gamma^2 e^3\right)\sin l$$

$$+\left(-10\gamma^4 e+\frac{65}{16}\gamma^2 e^3\right)\sin(2g+l)$$

$$+\frac{15}{16}\gamma^2 e^3\sin(2g-l)$$

$$+\left(-\frac{15}{4}\gamma^2 e'+\frac{65}{16}e^2 e'+\frac{5}{4}e'^3\right)\frac{a}{a'}\sin(\chi+l)$$

$$+\frac{25}{8}e^2 e'\frac{a}{a'}\sin(\chi-l)+\frac{5}{3}\gamma^2 e'\frac{a}{a'}\sin(\chi-2g-l)$$

and

$$\gamma_0^2\sin(2g_0+2l_0)=\gamma^2\sin(2g+2l)+\frac{5}{4}\gamma^2 e^2\sin 2l$$

$$+\left(5\gamma^4 e^2-\frac{5}{16}\gamma^2 e^4\right)\sin 2l+\left(\frac{5}{4}\gamma^4 e^2-\frac{5}{32}\gamma^2 e^4\right)\sin(2g+2l)$$

$$-\frac{25}{64}\gamma^2 e^4\sin(2g-2l)-\frac{5}{2}\gamma^4 e^2\sin(4g+2l)$$

$$+\frac{5}{3}\gamma^2 ee'\frac{a}{a'}\sin(\chi+2l)+\frac{15}{8}\gamma^2 ee'\frac{a}{a'}\sin(\chi+2g+2l)$$

$$+\frac{5}{8}\gamma^2 ee'\frac{a}{a'}\sin(\chi-2g-2l).$$

In both of which equations we may replace sines by cosines, changing signs where necessary. As a verification, we substitute these values in the terms of the elliptic expression, whose speed is three times the mean motion. These terms are,

$$\frac{13}{12}e_0^3\sin 3l_0-2\gamma_0^2 e_0\sin(2g_0+3l_0)-\frac{43}{64}e_0^5\sin 3l_0$$

$$+\left(-2\gamma_0^4 e_0+\frac{27}{4}\gamma_0^2 e_0^3\right)\sin(2g_0+3l_0)$$

$$-2\gamma_0^4 e_0\sin(4g_0+3l_0)$$

$$+\left(-2\gamma_0^6 e_0+\frac{27}{4}\gamma_0^4 e_0^3-\frac{207}{32}\gamma_0^2 e_0^5\right)\sin(2g_0+3l_0)$$

$$-\frac{9}{320}\gamma_0^2 e_0^5\sin(2g_0-3l_0)+\left(-4\gamma_0^6 e_0+\frac{45}{4}\gamma_0^4 e_0^3\right)\sin(4g_0+3l_0).$$

They become, after the substitutions have been performed,

$$\frac{13}{12}e^3\sin 3l-2\gamma^2 e\sin(2g+3l)$$

$$+\left(-\frac{5}{2}\gamma^2 e^3-\frac{43}{64}e^5\right)\sin 3l$$

$$+\left(-2\gamma^4 e-\frac{11}{8}\gamma^2 e^3\right)\sin(2g+3l)$$

$$+3\gamma^4 e\sin(4g+3l)$$

$$+\frac{65}{16}e^2e'\frac{a}{a'}\sin(\chi+3l)-\frac{5}{2}\gamma^2e'\frac{a}{a'}\sin(\chi+2g+3l)$$

$$+\left(-\frac{165}{8}\gamma^4e^3+5\gamma^2e^5\right)\sin 3l$$

$$+\left(-2\gamma^6e-\frac{49}{2}\gamma^4e^3+\frac{881}{64}\gamma^2e^5\right)\sin(2g+3l)$$

$$+\frac{1357}{640}\gamma^2e^5\sin(2g-3l)$$

$$+\left(21\gamma^6e-\frac{105}{16}\gamma^4e^3\right)\sin(4g+3l)$$

$$+\frac{325}{64}ee'^2\left(\frac{a}{a'}\right)^2\sin(2\chi+3l)$$

$$+\left(-\frac{895}{48}\gamma^2e^2e'+\frac{315}{32}e^4e'+\frac{65}{16}e^2e'^3\right)\frac{a}{a'}\sin(\chi+3l)$$

$$+\frac{2815}{256}e^4e'\frac{a}{a'}\sin(\chi-3l)$$

$$+\left(5\gamma^4e'-\frac{245}{16}\gamma^2e^2e'-\frac{5}{2}\gamma^2e'^3\right)\frac{a}{a'}\sin(\chi+2g+3l)$$

$$-\frac{505}{48}\gamma^2e^2e'\frac{a}{a'}\sin(\chi-2g-3l)-\frac{5}{6}\gamma^4e'\frac{a}{a'}\sin(\chi-4g-3l).$$

Delaunay omits the two terms

$$\frac{65}{16}e^2e'^3\frac{a}{a'}\sin(\chi+3l)-\frac{5}{2}\gamma^2e'^3\frac{a}{a'}\sin(\chi+2g+3l),$$

which he considers as being of the eighth order, on account of the smallness of e'. With this exception the expression just obtained agrees with the corresponding terms of Delaunay's expression. This verifies the algebraical work. Squaring and adding the expressions for $e_\circ\sin l_\circ$, $e_\circ\cos l_\circ$.

$$e_\circ^2=e^2-5\gamma^2e^2\cos 2g+\frac{5}{2}ee'\frac{a}{a'}\cos\chi$$

$$+\frac{45}{4}\gamma^4e^2-\frac{5}{2}\gamma^2e^4+\frac{25}{16}e'^2\frac{a^2}{a'^2}$$

$$+\left(-20\gamma^4e^2+\frac{25}{4}\gamma^2e^4\right)\cos 2g$$

$$+\left(-\frac{15}{2}\gamma^2ee'+\frac{15}{8}e^3e'+\frac{5}{2}ee'^3\right)\frac{a}{a'}\cos\chi$$

$$-\frac{115}{2}\gamma^2ee'\frac{a}{a'}\cos(\chi-2g).$$

Again, from the expressions for

$$\gamma_0^2 \sin(2g_0 + 2l_0),\ \gamma_0^2 \cos(2g_0 + 2l_0),$$

$$\gamma_0^2 \cos(2g_0 + 2l_0 - 2g - 2l) = \gamma^2 + \frac{5}{4}\gamma^2 e^2 \cos 2g$$

$$+ \left(\frac{5}{4}\gamma^4 e^2 - \frac{5}{32}\gamma^2 e^4\right) + \left(\frac{5}{2}\gamma^4 e^2 - \frac{5}{16}\gamma^2 e^4\right) \cos 2g$$

$$+ \frac{25}{64}\gamma^2 e^4 \cos 4g + \frac{5}{4}\gamma^2 e e' \frac{a}{a'} \cos \chi$$

$$+ \frac{5}{3}\gamma^2 e e' \frac{a}{a'} \cos(\chi - 2g)$$

and

$$\gamma_0^2 \sin(2g_0 + 2l_0 - 2g - 2l) = -\frac{5}{4}\gamma^2 e^2 \sin 2g$$

$$\therefore \gamma_0^2(1 - \cos(2g_0 + 2l_0 - 2g - 2l)) = \frac{25}{64}\gamma^2 e^4 (1 - \cos 4g)$$

$$\therefore \gamma_0^2 = \gamma^2 + \frac{5}{4}\gamma^2 e^2 \cos 2g + \left(\frac{5}{4}\gamma^4 e^2 + \frac{15}{64}\gamma^2 e^4\right)$$

$$+ \left(\frac{5}{2}\gamma^4 e^2 - \frac{5}{16}\gamma^2 e^4\right) \cos 2g + \frac{5}{4}\gamma^2 e e' \frac{a}{a'} \cos \chi$$

$$+ \frac{5}{3}\gamma^2 e e' \frac{a}{a'} \cos(\chi - 2g).$$

Correctly, therefore, to the fourth order e_0^2 must lie between

$$e^2 \pm 5\gamma^2 e^2 + 5 e e' \frac{a}{a'}$$

and γ_0^2 between

$$\gamma^2 \pm \frac{5}{4}\gamma^2 e^2$$

This result bears some resemblance to planetary theory.

The conditions of the problem would be approximately realised for a small satellite of *Neptune's* revolving near the surface of its primary.

Mean Areas and Heliographic Latitudes of Sun-spots in the year 1893, deduced from Photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius.

(*Communicated by the Astronomer Royal.*)

The results here given are in continuation of those printed in the *Monthly Notices*, vol. lv. p. 150, and are deduced from the measurements of solar photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn, India, and at the Royal Alfred Observatory, Mauritius.

Table I. gives the mean daily areas of umbræ, whole spots, and faculæ for each synodic rotation of the Sun in 1893, and Table II. gives the same particulars for the entire year 1893 and for the four preceding years for the sake of comparison. The areas are given in two forms. First, projected areas—that is to say, as seen and measured on the photographs—these being expressed in millionths of the Sun's apparent disc; and next, areas as corrected for foreshortening, the areas in this case being expressed in millionths of the Sun's visible hemisphere.

Table III. exhibits for each rotation in 1893 the mean daily area of whole spots, and the mean heliographic latitude of the spotted area, for spots north and for spots south of the equator, together with the mean heliographic latitude of the entire spotted area, and the mean distance from the equator of all spots; and Table IV. gives the same information for the year as a whole, similar results for 1889, 1890, 1891, and 1892 being added, as in the case of Table II. Tables II. and IV. are thus in continuation of the similar tables for the years 1874 to 1888, on pp. 381 and 382 of vol. xlix. of the *Monthly Notices*.

The rotations in Table I. and Table III. are numbered in continuation of Carrington's series (*Observations of Solar Spots made at Redhill*, by R. C. Carrington, F.R.S.), No. 1 being the rotation commencing 1853 November 9. The assumed prime meridian is that which passed through the ascending node at mean noon on 1854 January 1, and the assumed period of the Sun's sidereal rotation is 25·38 days. The dates of the commencement of the rotations are given in Greenwich civil time, reckoning from mean midnight.

Table I.

No. of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Mean Daily Areas. Projected. Umbræ.	Whole Spots.	Faculæ.	Corr. for Foreshortening. Umbræ.	Whole Spots.	Faculæ
	1892.							
525	Dec. 27·20	28	191	1190	1965	134	856	2096
	1893.							
526	Jan. 23·53	27	343	2122	2360	249	1571	2430
527	Feb. 19·87	26	223	1256	2092	154	907	2236
528	Mar. 19·20	28	228	1496	2290	162	1114	2367
529	Apr. 15·48	27	296	1886	2477	202	1342	2518
530	May 12·72	27	285	1959	2897	203	1456	2955
531	June 8·92	26	190	1329	2691	144	1085	2844
532	July 6·12	27	344	2150	2628	244	1574	2755
533	Aug. 2·33	28	532	3215	2949	381	2383	3152
534	Aug. 29·57	27	428	2544	2286	303	1802	2460
535	Sept. 25·84	27	335	1799	2313	253	1411	2458
536	Oct. 23·13	27	302	1662	1629	212	1197	1685
537	Nov. 19·43	28	319	2075	1259	233	1514	1351

TABLE II.

Year.	No. of Days on which Photographs were taken.	Mean Daily Areas. Projected. Umbræ.	Whole Spots.	Faculæ.	Corr. for Foreshortening. Umbræ.	Whole Spots.	Faculæ.
1889	360	17·9	103	107	13·1	78·0	131
1890	361	21·3	133	273	15·5	99·4	304
1891	363	120	745	1322	86·2	569	1412
1892	362	255	1596	3230	186	1214	3270
1893	362	327	1983	2287	234	1464	2404

TABLE III.

No of Rotation.	Date of Commencement of each Rotation.	No. of Days on which Photographs were taken.	Spots North of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Spots South of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
	1892.							
525	Dec. 27·20	28	183	+15·20	674	−16·91	−10·06	16·55
	1893.							
526	Jan. 23·53	27	318	+16·84	1253	−16·69	− 9·91	16·72
527	Feb. 19·87	26	411	+11·42	497	−14·52	− 2·79	13·12
528	Mar. 19·20	28	478	+15·63	636	−14·82	− 1·77	15·17
529	Apr. 15·48	27	580	+17·26	762	−16·90	− 2·13	17·06
530	May 12·72	27	453	+17·25	1002	−18·58	− 7·42	18·16
531	June 8·92	26	262	+14·35	822	−16·71	− 9·21	16·14
532	July 6·12	27	607	+14·44	967	−17·10	− 4·95	16·08
533	Aug. 2·33	28	632	+14·93	1751	−16·08	− 7·87	15·78
534	Aug. 29·57	27	538	+12·23	1264	−11·72	− 4·57	11·87
535	Sept. 25·84	25*	842	+12·04	474	−12·40	+ 3·23	12·17
536	Oct. 23·13	27	389	+15·18	808	− 8·30	− 0·67	10·54
537	Nov. 19·43	28	781	+18·52	733	− 7·06	+ 6·14	12·98

TABLE IV.

Year.	No. of Days on which Photographs were taken.	Spots North of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Spots South of the Equator. Mean of Daily Areas.	Mean Heliographic Latitude.	Mean Heliographic Latitude of Entire Spotted Area.	Mean Distance from Equator of all Spots.
1889	360	5·0	+ 7°·26	73·0	−11·90	−10·68	11°·61
1890	361	53·1	+22·20	46·3	−21·75	+ 1·73	21·99
1891	363	401	+20·49	169	−19·91	+ 8·52	20·31
1892	362	607	+15·09	607	−21·69	− 3·29	18·39
1893	360*	517	+14·91	941	−14·26	− 3·93	14·49

The principal features of the sun-spot record for 1893, as brought out by the above tables, are :—

(1) The increase in the mean daily area of umbræ and whole spots has been still continued, but in a greatly diminished ratio.

* The photographs on two days, October 20 and 22, have been used for the areas of the sun-spots, but not for their positions.

(2) But the mean daily area of the faculæ has undergone a notable decline.

(3) The predominance as to spotted area has changed over definitely from the northern hemisphere to the southern.

(4) The mean daily spotted area has actually declined for the northern hemisphere as compared with 1892, the increase recorded for the whole disc being entirely due to the great activity of the southern hemisphere.

(5) The mean distance from the equator of all spots has reached the zone usually occupied at maximum, and, indeed, for the last four rotations of the year, has considerably overpassed it. The extraordinary outburst of 1893 August, which was followed so promptly by this decline in latitude, probably marks, therefore, the actual crest of the curve at maximum.

(6) The decline in latitude has been mainly witnessed in the southern hemisphere, and set in, as just stated, immediately after the close of the great outburst for that hemisphere in August.

(7) On the whole the maximum as to spotted area appears to have fallen in 1893 August, both for the southern hemisphere and for the Sun as a whole. For the northern hemisphere considered separately, it seems to have fallen nearly fourteen months earlier, towards the end of June or beginning of July 1892.

Royal Observatory, Greenwich:
1895 *October* 28.

Diameters of Saturn and his Rings, observed at the Royal Observatory, Greenwich, during the Opposition of 1895.

(*Communicated by the Astronomer Royal.*)

Measures of *Saturn's* rings and of equatorial and polar diameters were made with the filar micrometer on the 28-inch refractor during the months of April, May, and June 1895, the full aperture being used in all cases.

The distances of the edge of the outer ring, of the centre of Cassini's division, of the edge of the inner bright ring, and of the crape ring were measured from the nearer and further limbs of the planet, both on the preceding and following sides; the mean of two such measures giving the radius of a ring, and the difference giving the equatorial diameter of *Saturn*. Direct measures were also made of the polar diameter and of the width of Cassini's division. The latter was sharply defined, and was easy to measure, and seemed a little more distinct on the following than on the preceding side. Encke's division was seen at both ansæ on June 12 by the Astronomer Royal and Mr. Lewis.

The results obtained on the separate nights are given in the following table, as well as the number of separate determinations of each result. In the column "Observer" D denotes Mr. Dyson, and L Mr. Lewis. The measures have all been reduced to a mean distance of 9·53885, and the polar diameters have been corrected for the elevation of the earth above the plane of the ring.

Date.	Observer.	Power.	Diameters of *Saturn*. Equatorial.	Polar.	Outer radius of Outer Ring. Preceding.	Following.	Width of Cassini's Division. Preceding.	Following.	Radius to centre of Cassini's Division. Preceding.	Following.	Inner radius of Inner Bright Ring. Preceding.	Following.	Inner radius of Crape Ring. Preceding.	Following.
1895.														
Apr. 13	L.	670	17″.56 20	″ ...	20″.12 10	20″.18 10	″ ...	″ ...	″ ...	″ ...	′ ...	′ ...	′ ...	″ ...
14	D.	670	·71 19	16 72 7	·40 6	·17 3	...	...	17·22 7	17·17 4	12·48 6	...	...	...
23	L.	670	·92 48	17·20 7	·40 8	·26 8	0·53 4	0·61 4	·27 8	·37 8	·94 8	12·85 8	10·53 8	10·38 8
28	D.	670	·67 50	15·91 10	·09 8	·09 8	·49 4	·55 4	·11 8	·12 8	·45 8	·42 10	...	...
29	L.	670	·71 32	...	·13 8	·17 8	·52 4	·55 4	·19 8	·42 8	·86 6	13·00 6	·76 6	·50 6
May 11	L.	670	·71 22	16·71 11	·36 4	·26 6	·46 4	·48 4	·09 6	·19 6	13·01 6	12·89 6	...	...
13	L.	670	·79 10	17·02 9	...	...	...	...	...	...	...	...	...	...
31	L.	670	·88 20	...	·37 10	·53 10	·62 4	·44 2	17·13 6	...	...	...	·21 4	9·98 4
June 2	D.	480	...	...	...	...	·46 7	·41 6	...	...	...	...	...	...
6	L.	480	·81 10	...	·42 5	·53 5	...	...	...	...	...	...	...	...
7	L.	670	17·74 12	17·20 10	·06 6	·45 6	·40 4	·44 4	16·80 6	17·13 6	13·02 6	13·11 6	·20 4	10·13 4
12	L.	670	18·01 15	...	·26 5	...	·54 6	·65 6	...	...	...	...	·09 6	·03 6
18	L.	670	...	...	...	...	·51 4	·55 4	...	...	...	...	...	...
26	L.	670	17·53 6	...	20·27 4	20·64 4	0·54 4	0·67 3	...	...	...	...	10·42 2	10·35 2
Mean			17·754 254	16·793 54	20·262 74	20·328 70	0·507 45	0·535 37	17·116 49	17·233 40	12·793 40	12·854 36	10·368 30	10·397 30

In addition to this, the position-angle of the major axis of the rings was measured with the following results :—

Date.	Position-angle of Major Axis.	Date.	Position-angle of Major Axis.
	° ′		° ′
Apr. 13	359 24	June 6	358 38
14	358 2	7	359 20
23	360 18	12	360 0
29	359 24	18	361 20
May 11	359 23	20	361 15
13	359 22	26	360 10
31	359 15		

The diameter of *Titan* was measured on three nights as follows :—

Date.	Diameter of *Titan*.	No. of Measures.
	″	
Apr. 23	0·990	6
May 11	0·828	11
June 12	1·028	4
	0·950	21

The mean results of the measures are given below, together with those obtained by Professor Hall at Washington 1885–1887, and by Professor Barnard at the Lick Observatory, Mount Hamilton, in 1895.

	Greenwich.	Mt. Hamilton.	Washington.
	″	″	″
Equatorial diameter of Saturn ...	17·754	17·744	17·72
Polar diameter of Saturn	16·793	16·307	...
Outer diameter of Outer Ring ...	40·590	40·249	40·45
Inner diameter of Outer Ring ...	34·870	34·864	34·95
Centre of Cassini's Division ...	34·349	34·306	34·53
Outer diameter of Inner Ring ...	33·828	33·748	34·11
Inner diameter of Inner Ring ...	25·647	25·522	25·75
Inner diameter of Crape Ring ...	20·765	20·737	20·52
Width of Cassini's Division ...	0·521	0·558	0·42
Width of Outer Ring	2·860	2·693	2·750
Width of Inner Ring	4·091	4·113	4·180
Width of Crape Ring	2·382	2·393	2·625

The following table, based on 92,797,000 miles, as mean distance of the Earth from the Sun, gives the actual dimensions of *Saturn's* system as determined at these three observatories :—

	Greenwich. (miles)	Mt. Hamilton. (miles)	Washington. (miles)
Equatorial diameter of Saturn ...	76,190	76,150	76,050
Polar diameter of Saturn	72,066	69,980	...
Outer diameter of Outer Ring ...	174,190	172,730	173,590
Inner diameter of Outer Ring ...	149,640	149,620	149,990
Outer diameter of Inner Ring ...	145,170	144,830	146,380
Inner diameter of Inner Ring ...	110,060	109,530	110,500
Inner diameter of Crape Ring ...	89,110	88,990	88,060
Width of Cassini's Division ...	2,240	2,400	1,800
Width of Outer Ring	12,270	11,560	11,800
Width of Inner Ring	17,560	17,650	17,940
Width of Crape Ring	10,220	10,270	11,260

The agreement of the Greenwich, Mount Hamilton, and Washington results is very satisfactory, except in the case of the polar diameter, of which a comparatively small number of measures were made at Greenwich. If the low declination of the planet permits, it is intended to supplement these by more measures of the polar diameter at the next opposition.

Meridian Observations of Sirius and Procyon at the Royal Observatory, Greenwich, 1836–1894. By W. G. Thackeray.

In reducing a long series of observations such as the above to a common epoch, it is very essential to make the reductions on as homogeneous a system as possible, a matter of no little difficulty and trouble.

The following right ascensions were made with the transit instrument from 1836–1850, and with the transit circle from 1851–1894.

The difficulty of adjusting the observed right ascensions of stars to a fixed point—the point where the Sun crosses the Equator at the spring equinox—has been met by correcting the adopted places of those stars which have been used to ascertain the errors of the transit clock in accordance with the quantities given annually in the "Greenwich Observations" under the section of discussions of the position of the Ecliptic—a correction which for brevity we may refer to as the correction to the equinox. The opportunity for making such a correction has always been chosen at the time of making one of the periodical catalogues, and reference to the introduction to any of these catalogues will show the method observed.

In this investigation the equinox of the 1880 catalogue has been adopted as the standard of reference in forming the adopted right ascensions for 1890.

The following table gives the necessary corrections and the

data on which they are founded. The first column, (1), gives the years corresponding to the various catalogues. The second column, (2), gives the authority for the places of the clock-star list as adopted in the reductions. For instance, in 1836 the authority was a catalogue of star places given in the *Nautical Almanac* for 1834, 2nd edition; and this catalogue as corrected by quantities given in the introductions to the "Greenwich Observations" was used till 1843, when the places of the Greenwich 1840 Catalogue were used; and these were used until 1849, when the places of the Greenwich 1845 Catalogue were used, and so on. The third column, (3), gives the corrections that are required to bring the clock-star system used in the reductions of different years to a uniform system for each catalogue. Column (4) gives the apparent correction to the equinox for the series of years forming the catalogue from the observation of the Sun as depending on the system of clock stars used for each year's reductions. Column (5) is the mean of the corrections taking column (4)–column (3) for each catalogue. Column (6) gives the correction to the equinox for each year after the clock stars have been reduced to a uniform system, and is the sum of columns (5) and (3). Column (7) is the mean of the corrections in column (6) for the series of years forming the different catalogues, and which may be taken as the systematic catalogue correction to the adopted clock-star places. Column (8) is the correction to the various catalogues to reduce them to the adopted equinox of the 1880 catalogue, and column (9), which is the sum of (6) and (8), gives the correction required to reduce the mean right ascensions of each individual year to the equinox of the 1880 catalogue—that is to say, what the observed right ascension would have been had the standard right ascensions of the Ten-year Catalogue 1880 been used throughout as the authority for the annual clock-star lists, always assuming the validity of the so-called correction to the equinox.

Corrections required to reduce Mean Right Ascensions of the Annual Catalogues of the Greenwich Observations to the Equinox of the 1880 *Catalogue.*

TABLE I.

Year.	Authority for Clock-Star List.	Correction to adopted Clock-Star System.	Apparent Correction to Equinox.	Assumed Correction to Equinox.	Adopted Correction to Equinox for Annual Mean R.A.'s.	Resulting Mean Correction to Catalogue.	Correction to reduce Catalogues to Equinox of 1880 Cat.	Correction to reduce Annual Mean R.A.'s to Equinox of 1880 Cat.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		s	s	s	s	s	s	s
1836	Catalogue in	+ ·029	−·130		−·081			−·052
1837	N.A. 1834,	+ ·034	−·048		−·076			−·047
1838	2nd edition,	+ ·024	−·137		−·086			−·057
1839	corrected by	+ ·025	−·074	−·110	−·085	−·084	+·029	−·056
1840	quantities	+ ·022	−·089		−·088			−·059
1841	given in introductions	+ ·020	−·026		−·090			−·061
	to Greenwich observations							

Year.	Authority for Clock-Star List.	Correction to adopted Clock-Star System.	Apparent Correction to Equinox.	Assumed Correction to Equinox.	Adopted Correction to Equinox for Annual Mean R.A.'s.	Resulting Mean Correction to Catalogue.	Correction to reduce Catalogues to Equinox of 1880 Cat.	Correction to reduce Annual Mean R.A.'s to Equinox of 1880 Cat.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		s	s	s	s	s	s	s
1842		+ ·022	− ·061		− ·021			− ·076
1843	1840 Cat.	+ ·111	+ ·101		+ ·068			+ ·013
1844		+ ·099	+ ·010	− ·043	+ ·056	+ ·045	− ·055	+ ·001
1845		+ ·120	+ ·093		+ ·077			+ ·022
1846		+ ·081	+ ·087		+ ·038			− ·017
1847		+ ·093	+ ·037		+ ·050			− ·005
1848		+ ·062	+ ·186		+ ·072			+ ·062
1849	1845 Cat.		− ·038		+ ·010			000
1850			− ·064	+ ·010	+ ·010	+ ·020	− ·010	000
1851			− ·019		+ ·010			000
1852			+ ·033		+ ·010			000
1853			+ ·022		+ ·010			000
1854		+ 0·009	+ ·061		000			+ ·010
1855		+ 0·009	− ·011		000			+ ·010
1856	1850 Cat.		− ·068		− ·010			000
1857			− ·016	− ·010	− ·010	− ·007	+ ·010	000
1858			− ·025		− ·010			000
1859			+ ·044		− ·010			000
1860			− ·019		− ·010			000
1861		000	− ·001					
1862	1860 Cat.		− ·005					
1863			+ ·008					
1864			− ·002	− ·010	− ·010	− ·010	+ ·003	− ·007
1865			− ·010					
1866			− ·006					
1867			− ·051					
1868		000	− ·050					
1869		000	− ·001					
1870	1864 Cat.		− ·012					
1871			+ ·044					
1872			− ·019	+ ·007	+ ·007	+ ·007	− ·007	000
1873			+ ·058					
1874			− ·049					
1875			+ ·038					
1876			+ ·055					

Year.	Authority for Clock-Star List.	Correction to adopted Clock-Star System.	Apparent Correction to Equinox.	Assumed Correction to Equinox.	Adopted Correction to Equinox for Annual Mean R.A.'s.	Resulting Mean Correction to Catalogue.	Correction to reduce Catalogues to Equinox of 1880 Cat.	Correction to reduce Annual Mean R.A.'s to Equinox of 1880 Cat.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		s	s	s	s	s	s	s
1877		+ ·013	+ ·044		+ ·013			+ ·013
1878	1872 Cat.		− ·049					
1879			+ ·025					
1880			− ·092					
1881			− ·035					
1882			− ·027	000	000	+ ·000		000
1883			− ·002					
1884			+ ·084					
1885			− ·009					
1886			+ ·094					

The observations of north polar distances were made with the Jones and Troughton Circles for the years 1836–39, with the Troughton Circle 1840–47, with the Troughton and Jones Cape Circle for the year 1848, with the Troughton Circle for the years 1849–50, and with the Transit Circle 1851–94.

For the years 1836–47 the position of these circles was o″·07 N. of the Transit Circle; 1848–50 the Troughton Circle was o″·04 S. of the Transit Circle. See "Systematic Errors of the Greenwich Transit Circle," by W. H. M. Christie, *Memoirs R.A.S.* vol. xiv. pp. 156, 157.

The north polar distances for the years 1836–47 have been corrected to colatitude 21″·83; those of 1849–50 to colatitude 21″·94, and those of 1851–94 to colatitude 21″·90.

The following table (II.) exhibits the corrections which are necessary to be applied to the results of each year's observations, as given in the various annual catalogues of Greenwich observations, to reduce the observations of 1836–50 to Bessel's refractions and colatitude of the present Greenwich Transit Circle, 38° 31′ 21″·90, and the Transit Circle observations to the following system :—

Flexure = o″·00.
Bessel's refractions (*Tabulæ Regiomontanæ*).
Colatitude 38° 31′ 21″·90.
Formula of $R - D = a + b \sin z$.

In addition, corrections have also been applied to the results of the years 1868-76 for the wear of the microscope micrometer screws.

No corrections have been applied for Dr. Chandler's latitude variation.

TABLE II.

Corrections required to reduce Mean North Polar Distances of Sirius and Procyon in Annual Catalogues of the Greenwich Observations to a uniform system.

	Sirius.				*Procyon.*			
Year.	Colatitude 21″·90 and Bessel's Refractions.	Flexure ·00 R−D $a+b$ sin z.	Wear of Microscopes.	Sum.	Colatitude 21″·90 and Bessel's Refractions.	Flexure ·00 R−D $a+b$ sin z	Wear of Microscopes.	Sum.
	″	″	″	″	″	″	″	″
1836–38	−0·10	...	...	−0·10	−0·10	...	...	−0·10
1839	+0·16	...	...	+0·16	+0·16	...	...	+0·16
1840	+0·13	...	...	+0·13	+0·13	...	...	+0·13
1841–48	+0·03	...	...	+0·03	+0·03	...	...	+0·03
1849–50	+0·14	...	...	+0·14	+0·14	...	...	+0·14
1851–53	+0·10	...	...	+0·10	+0·10	...	...	+0·10
1854–60	−0·10	...	...	−0·10	−0·10	...	...	−0·10
1861	+0·10	...	...	+0·10	+0·10	...	...	+0·10
1862	+0·10	−0·34	...	−0·24	+0·10	−0·10	...	0·00
1863	+0·10	−0·40	...	−0·30	+0·10	−0·16	...	−0·06
1864	+0·10	−0·29	...	−0·19	+0·10	−0·10	...	0·00
1865	+0·10	−0·50	...	−0·40	+0·10	−0·16	...	−0·06
1866	+0·10	+0·52	...	+0·62	+0·10	+0·16	...	+0·26
1867	+0·10	+0·38	...	+0·48	+0·10	+0·14	...	+0·24
1868	+1·04	+0·60	+0·13	+1·77	+0·62	+0·20	0·00	+0·82
1869	+1·04	+0·53	+0·15	+1·72	+0·62	+0·20	+0·03	+0·85
1870	+1·04	+0·47	+0·04	+1·55	+0·62	+0·17	−0·05	+0·74
1871	+1·04	+0·47	+0·26	+1·77	+0·62	+0·17	+0·04	+0·83
1872	+1·04	+0·36	−0·08	+1·32	+0·62	+0·13	−0·04	+0·71
1873	+1·04	+0·40	+0·30	+1·74	+0·62	+0·14	−0·01	+0·75
1874	+1·04	+0·37	...	+1·41	+0·62	+0·13	...	+0·75
1875	+1·04	+0·21	...	+1·25	+0·62	+0·07	...	+0·69
1876	+1·04	+0·24	...	+1·28	+0·62	+0·08	...	+0·70
1877–94	...	...	...	0·00	...	...	...	0·00

The following table (III.) gives the mean observed right ascensions and north polar distances of *Sirius*, as taken from the annual catalogues of the Greenwich observations reduced to 1890 by the use of Peters' constants of precession, and corrected, by Tables I. and II., with (*a*) Professor Auwers' proper motions $-0^{s}\cdot0372$ and $+1''\cdot199$, and (*b*) corrected proper motion in N.P.D. of $+1''\cdot229$.

The following diagrams exhibit the finally adopted places for 1890, first of all compared with orbital corrections given by

Professor Auwers in the *Astr. Nachr.* No. 3085 ; and secondly, as corrected by the same quantities. And assuming that these latter are correct, then the Greenwich observations appear to show that a correction of + 0″·030 should be applied to Professor Auwers' value of the proper motion in N.P.D.

Table III.

Mean Right Ascensions and North Polar Distances of Sirius reduced to 1890·0, *with Peters' Constants of Precession and* (*a*) *Auwers' Proper Motion,* (*b*) *Corrected Proper Motion in N.P.D.*

Year and fraction of year.	Mean Right Ascension.	No. of Obs.	Adopted Seconds of R.A. 1890·0.	Year and fraction of year.	Mean North Polar Distance.	No. of Obs.	Adopted Seconds of N.P.D. 1890·0.	
							(*a*)	(*b*)
	h m s		s		° ′ ″		″	″
1836·36	6 37 55·340	23	18·060	1836·31	106 29 48·91	28	57·48	59·10
1837·43	58·030	17	·110	1837·50	53·94	131	58·02	59·61
1838·34	38 0·660	21	·090	1838·44	58·19	30	57·77	59·33
1839·31	3·360	26	·150	1839·46	30 1·55	22	56·87	58·41
1840·25	6·010	30	·130	1840·48	6·22	17	57·00	58·50
1841·31	8·630	12	·100	1841·36	11·11	6	57·26	58·73
1842·39	11·320	32	·130	1842·45	14·77	11	56·38	57·82
1843·43	13·930	16	·180	1843·45	18·15	13	55·24	56·65
1844·50	16·510	13	·100	1844·49	22·49	9	55·06	56·44
1845·31	19·140	17	·110	1845·43	26·34	10	54·37	55·72
1846·29	21·770	27	·050	1846·40	31·05	10	54·54	55·86
1847·26	24·360	22	·010	1847·44	35·64	5	54·57	55·86
1848·30	27·030	27	·130	1848·39	40·12	11	54·82	56·08
1849·40	29·680	38	·080	1849·36	44·84	23	54·90	56·13
1850·32	32·330	21	·080	1850·31	50·23	25	55·65	56·85
1851·31	34·970	24	·070	1851·29	53·41	27	54·14	55·31
1852·30	37·600	29	·060	1852·30	58·54	26	54·62	55·76
1853·21	40·210	7	18·030	1853·26	31 3·34	8	55·74	56·85
1854·33	42·800	13	17·990	1854·37	8·04	15	54·97	56·05
1850·32	45·490	15	18·030	1855·37	12·61	16	54·97	56·02
1856·42	48·130	9	18·010	1856·42	17·46	9	55·24	56·26
1857·38	50·710	13	17·950	1857·39	23·00	12	56·20	57·19
1858·50	53·290	10	·890	1858·45	28·12	9	56·73	57·69
1859·34	55·990	11	·950	1859·34	32·05	11	56·07	57·00
1860·45	58·610	7	·920	1860·39	37·30	6	56·73	57·63
1861·38	39 1·240	9	·910	1861·44	40·75	8	55·89	56·76
1862·88	6 39 3·880*	2	·910	1862·57	106 31 47·21*	2	57·28	58·12

* One observation in this year's result has been rejected.

Right Ascensions of Sirius observed at the Royal Observatory, Greenwich 1836-1894 reduced to 1890 with Auwers' proper motion, compared with Auwers' corrections for orbital motion Astronomische Nachrichten No 3085.

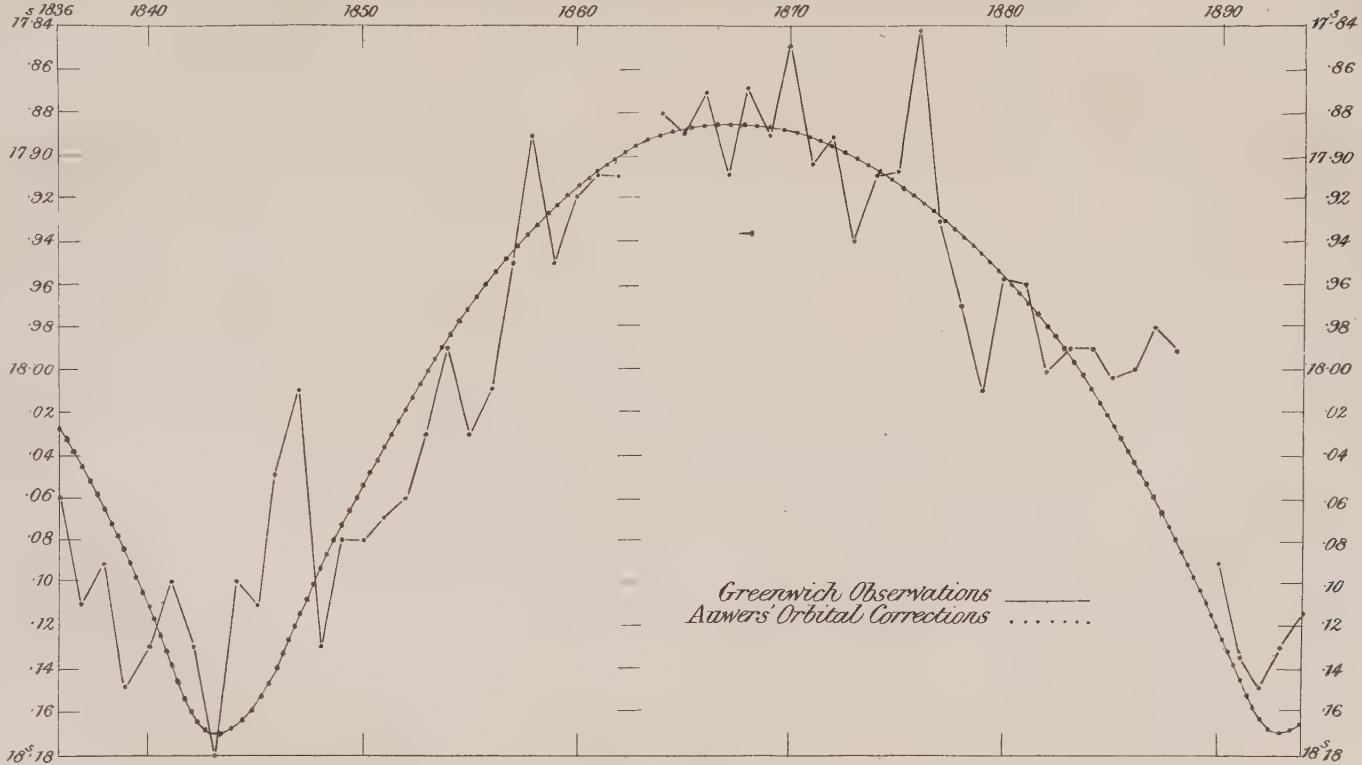


DIAGRAM (I)

North Polar Distances of Sirius observed at the Royal Observatory, Greenwich 1836-1894 reduced to 1890 with (a) Auwers' Proper motion +1".199; (b) adopted proper motion + 1".229; compared with Auwers's corrections for orbital motion (Ast. Nach. N.° 3085.)

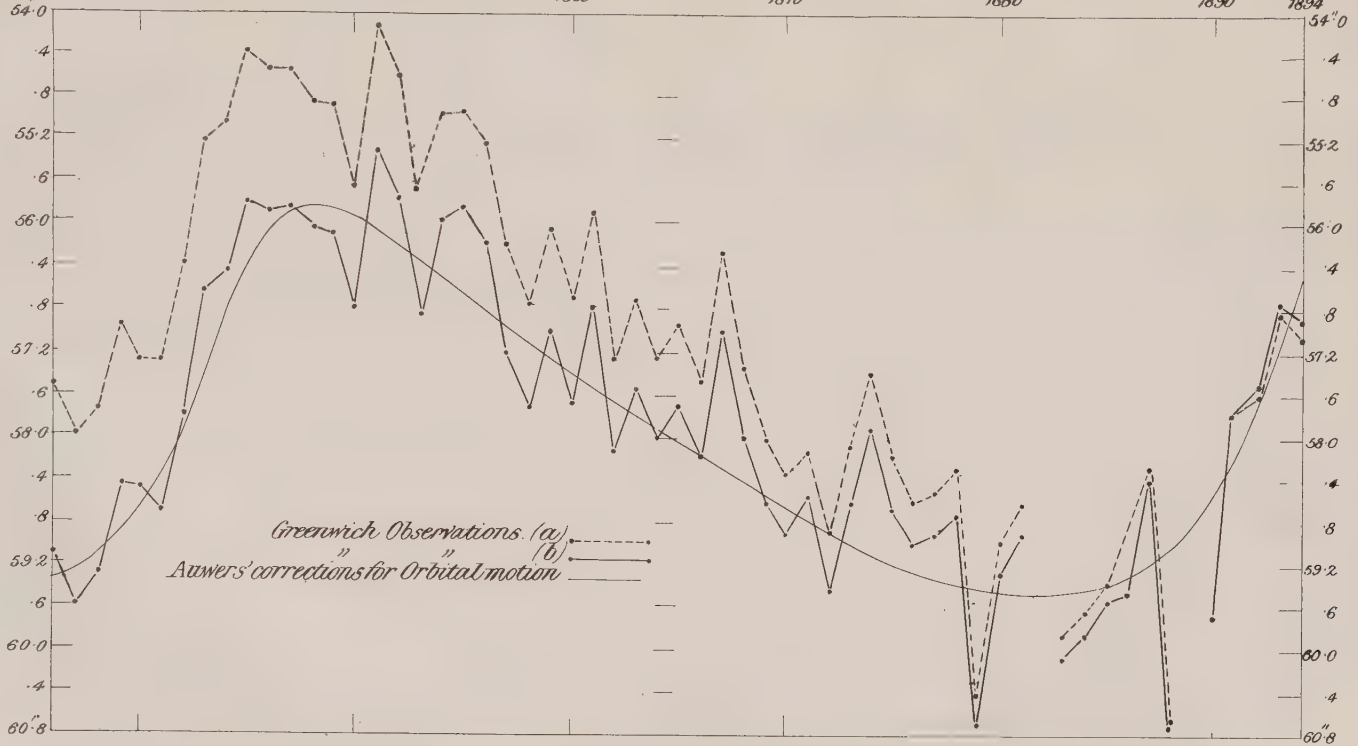


DIAGRAM (2)

Right Ascensions of Sirius observed at the Royal Observatory, Greenwich 1836 - 1894 reduced to 1890 with Auwers' correction for linear and orbital motions.

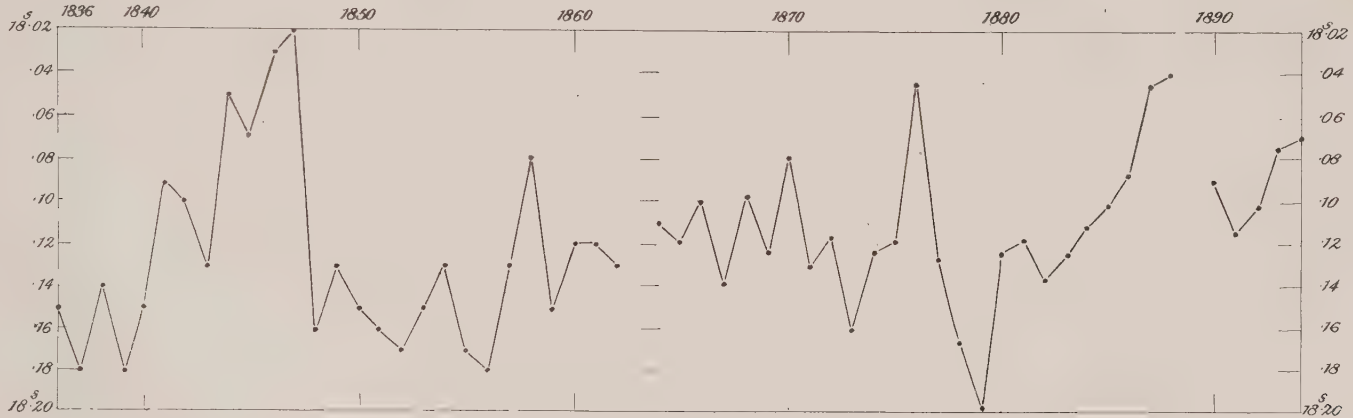


DIAGRAM (3)

North Polar Distances of Sirius made at the Royal Observatory, Greenwich, 1836-1894 reduced to 1890 with Auwers' correction for linear and orbital motions.

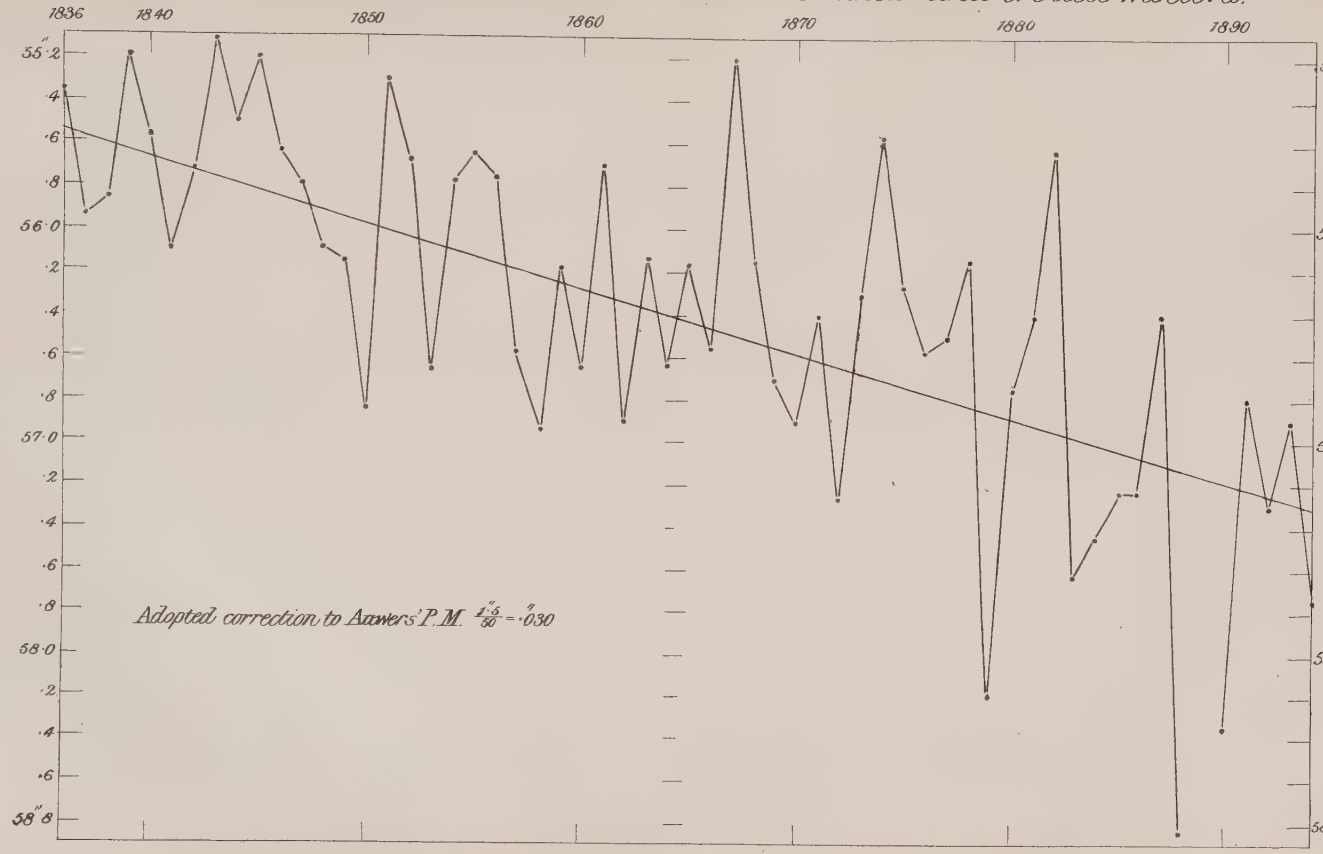


DIAGRAM (4)

Year and fraction of year.	Mean Right Ascension.	No. of Obs.	Adopted Seconds of R.A. 1890·0.	Year and fraction of year.	Mean North Polar Distance.	No. of Obs.	Adopted Seconds of N.P.D. 1890·0.	
							(*a*)	(*b*)
	h m s		s		° ′ ″		″	″
1863·00	6 39 ...	...	...	1863·83	106 31 51·28	1	56·70	57·51
1864·29	9·140	18	·880	1864·28	56·34	15	57·26	58·04
1865·27	11·800	18	17·890	1865·27	32 0·83	18	56·93	57·68
1866·38	14·420	13	17·870	1866·38	4·95	13	57·46	58·18
1867·47	17·100	6	·910	1867·43	9·50	7	56·26	56·95
1868·52	19·710	8	·866	1868·51	12·85	9	57·33	57·99
1869·46	22·380	3	·893	1869·45	18·22	6	58·01	58·64
1870·44	24·980	7	·849	1870·44	23·35	7	58·33	58·93
1871·49	27·730	6	·905	1871·49	27·37	6	57·93	58·50
1872·41	30·310	3	·891	1872·41	33·43	3	58·90	59·44
1873·70	33·005	4	·942	1873·70	38·85	4	58·10	58·61
1874·48	35·615	4	·908	1874·47	41·12	5	57·40	57·88
1875·21	38·258	8	·907	1875·26	46·71	6	58·19	58·64
1876·59	40·836	5	·842	1876·43	51·72	5	58·59	59·01
1877·15	43·560	4	·929	1877·15	57·66	4	58·57	58·96
1878·51	46·253*	4	17·979	1878·50	33 2·05*	4	58·30	58·66
1879·31	48·937	3	18·020	1879·31	8·82	3	60·39	60·72
1880·31	51·516	5	17·955	1880·31	12·08	5	58·98	59·28
1881·19	54·165	2	17·959	1881·19	16·42	2	58·65	58·92
1882·97	56·850	1	18·003	1882·97	(20·29)	1	(57·88)	(58·12)
1883·14	59·486	5	17·993	1883·13	26·99	13	59·88	60·09
1884·11	40 2·130	1	17·993	1884·11	31·47	2	59·68	59·86
1885·35	4·785	4	18·005	1885·47	35·82	3	59·38	59·53
1886·13	7·426	5	18·002	1886·15	40·44	5	59·32	59·44
1887·13	10·050	½	17·981	1887·13	44·16	1	58·28	58·37
1888·04	12·705	2	17·993	1888·04	51·27	2	60·69	60·75
1889	...	...	...	1889	...	...	...	...
1890·12	18·087	3	18·087	1890·09	59·73	2	59·73	59·73
1891·16	20·780	2	·136	1891·16	34 2·47	2	57·76	57·73
1892·71	23·438	4	·150	1892·71	6·99	4	57·55	57·49
1893·21	26·059	14	·127	1893·21	10·98	17	56·85	56·76
1894·42	6 40 28·690	5	·114	1894·42	106 34 15·86	5	57·06	56·94

After applying Professor Auwers' corrections for linear and orbital motions, and giving equal weights to the result of each year's observations, the mean right ascension and north polar dis-

tance of *Sirius* for 1890·0 are $6^h\ 40^m\ 18^s{\cdot}118$ and 106° 33′ 57″·18, and with the corrected proper motion in N.P.D. 106° 33′ 58″·00.

The following table (IV.) gives the mean right ascensions and north polar distances of *Procyon* as taken from the annual catalogues of Greenwich observations reduced to 1890, by the use of Peters' constants of precession, and corrected by Tables I. and II., with Professor Auwers' proper motions of $-0^s{\cdot}0474$ and $+1''{\cdot}027$. The following diagrams exhibit the finally adopted places for 1890, first of all compared with the corrections for orbital motion given by Professor Auwers in *Astr. Nachr.*, Nos. 1371–2–3; and secondly, as corrected by the same quantities.

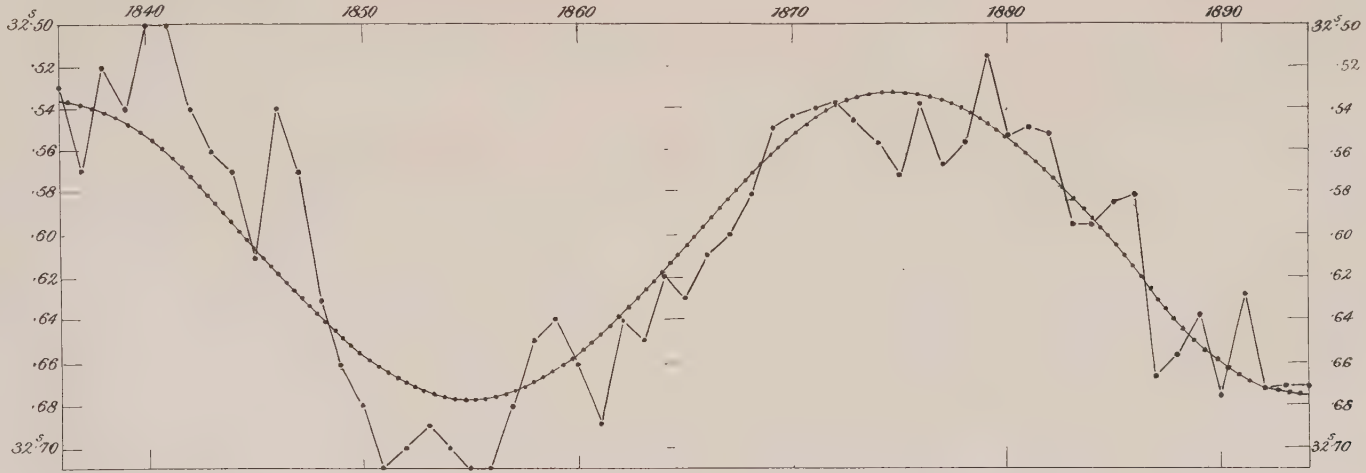
After applying Professor Auwers' corrections for linear and orbital motions, and giving equal weights to the result of each year's observations, the mean right ascension and north polar distance for 1890·0 are $7^h\ 33^m\ 32^s{\cdot}605$ and 84° 29′ 36″·98.

TABLE IV.

Mean Right Ascensions and North Polar Distances of Procyon reduced to 1890·0 *with Peters' constants of Precession and Auwers' proper motion.*

Year and Fraction.	Mean Right Ascension.	No. of Obs.	Adopted Seconds of R.A. 1890.	Year and Fraction.	Mean North Polar Distance.	No. of Obs.	Adopted Seconds of N.P.D. 1890.
	h m s		s		° ′ ″		″
1836·30	7 30 42·770	27	32·530	1836·33	84 21 38·30	12	37·31
1837·38	45·950	27	·570	1837·62	46·20	12	36·46
1838·28	49·060	24	·520	1838·47	55·29	22	36·79
1839·32	52·220	17	·540	1839·43	22 3·60	13	36·59
1840·30	55·350	25	·500	1840·62	11·10	6	35·18
1841·25	58·500	17	·500	1841·29	21·74	8	37·03
1842·40	31 1·680	33	·540	1842·41	28·95	10	35·49
1843·41	4·760	21	·560	1843·38	38·25	9	36·01
1844·41	7·930	25	·570	1844·44	46·94	7	35·91
1845·34	11·090	23	·610	1845·54	55·94	6	36·11
1846·31	14·210	20	·540	1846·23	23 3·88	11	35·24
1847·39	17·370	31	·570	1847·40	14·04	4	36·59
1848·37	20·510	32	·630	1848·23	21·60	13	35·48
1849·31	23·740	25	·660	1849·35	30·33	12	35·44
1850·30	26·910	30	·680	1850·24	39·94	18	36·16
1851·42	30·090	28	·710	1851·41	48·96	24	36·28
1852·28	33·220	44	·700	1852·27	58·14	33	36·56
1853·22	36·360	7	·690	1853·19	24 6·75	1	36·27
1854·31	39·500	28	·700	1854·38	16·23	21	36·96
1855·35	42·650	20	·710	1855·35	25·43	19	37·32
1856·32	7 31 45·800	12	·710	1856·40	84 24 34·15	14	37·19

Right Ascensions of Procyon made at the Royal Observatory, Greenwich 1836-1894 reduced to 1890 with Auwers Proper Motion, compared with Auwers' corrections for orbital motion. (Astronomische Nachrichten Nos. 1371-2-3.)



Greenwich Observations ———
Auwers' Corrections ·-·-·-·-·

DIAGRAM (5)

North Polar Distances of Procyon made at the Royal Observatory, Greenwich 1836-1894 reduced to 1890·0 with Auwers' Proper Motion compared with Auwers' corrections for orbital motion Astronomische Nachrichten Nos 1371-2 3.

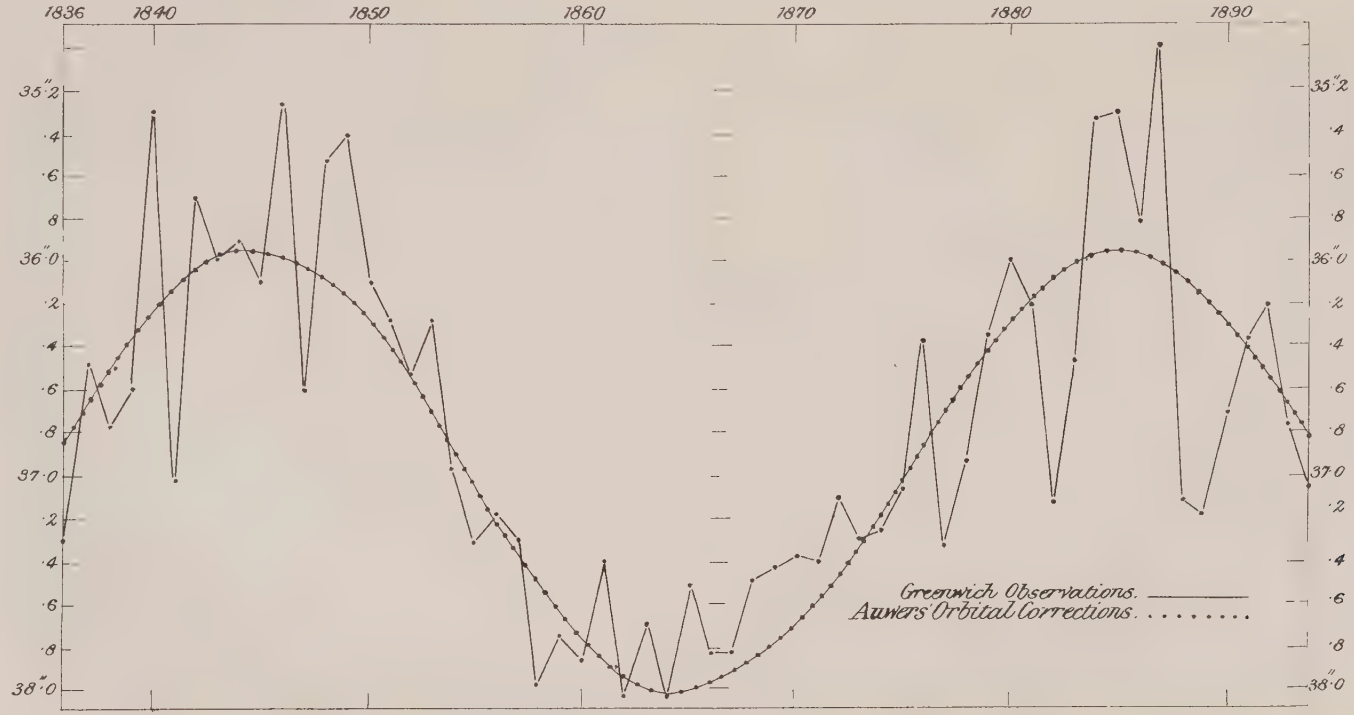


DIAGRAM (6)

Right Ascensions & North Polar Distances of Procyon made at the Royal Observatory, Greenwich, 1836-1894 reduced to 1890 with Auwers' corrections for linear and orbital motions.

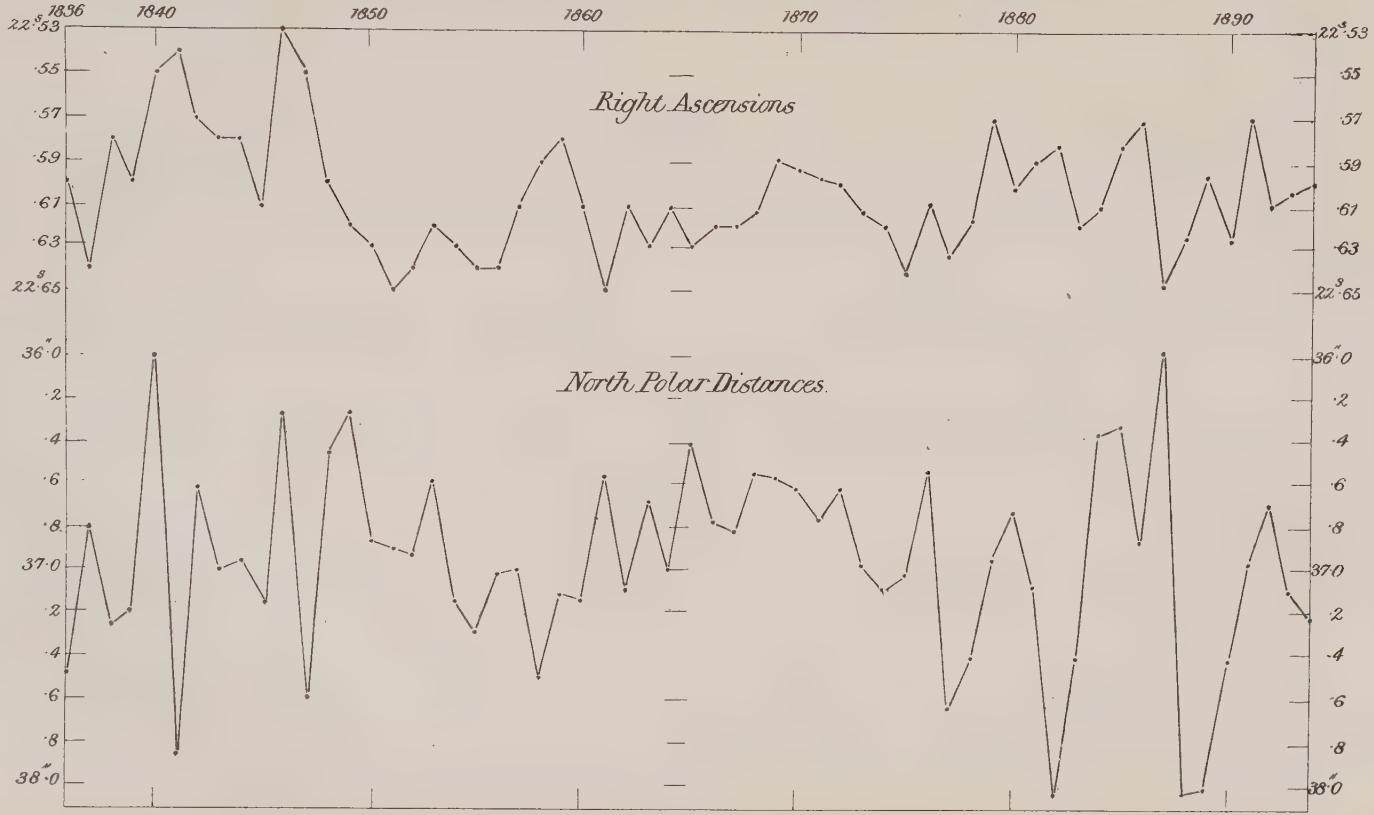


DIAGRAM (7)

Year and Fraction.	Mean Right Ascension.	No. of Obs.	Adopted Seconds of R.A. 1890.	Year and Fraction.	Mean North Polar Distances.	No. of Obs.	Adopted Seconds of N.P.D. 1890
	h m s		s		° ′ ″		″
1857·44	7 31 48·920	22	·680	1857·51	8 24 43·12	16	37·31
1858·41	52·030	17	·650	1858·48	52·65	13	37·99
1859·55	55·170	9	·640	1859·53	25 1·26	9	37·74
1860·37	58·380	10	·660	1860·33	10·27	5	37·86
1861·35	32 1·510	6	·690	1861·51	18·43	4	37·40
1862·67	4·600	5	·640	1862·54	28·06	6	38·05
1863·23	7·760	10	·650	1863·26	36·61	7	37·66
1864·39	10·870	14	·620	1864·42	45·83	12	38·06
1865·39	14·020	20	·630	1865·38	54·16	15	37·46
1866·31	17·150	12	32·610	1866·35	26 3·09	8	37·82
1867·41	20·280	15	·600	1867·49	12·00	9	37·83
1868·45	23·420	16	·582	1868·50	19·93	12	37·49
1869·37	26·530	16	·548	1869·44	28·75	11	37·42
1870·34	29·670	15	·544	1870·42	37·70	13	37·36
1871·39	32·810	23	·541	1871·45	46·57	20	37·39
1872·33	35·950	19	·537	1872·45	55·30	16	37·09
1873·40	39·104	10	·547	1873·44	27 4·38	11	37·30
1874·28	42·255	10	·555	1874·48	13·25	4	37·25
1875·42	45·418	10	·574	1875·53	22·01	12	37·04
1876·55	48·527	14	·539	1876·65	30·24	7	36·36
1877·41	51·697	11	·568	1877·54	40·80	9	37·33
1878·47	54·828	13	·555	1878·48	49·35	13	36·93
1879·34	57·925	6	·513	1879·38	57·72	8	36·35
1880·42	33 1·115	10	·554	1880·42	28 6·31	9	35·99
1881·49	4·254	11	·549	1881·46	15·48	6	36·21
1882·59	7·400	5	·551	1882·64	25·31	1	37·11
1883·50	10·590	6	·597	1883·46	33·63	6	36·47
1884·41	13·735	11	·598	1884·51	41·42	7	35·33
1885·27	16·865	8	·585	1885·33	50·34	6	35·29
1886·55	20·006	7	·582	1886·48	59·81	6	35·83
1887·46	23·238	12	·669	1887·52	29 8·01	8	34·97
1888·54	26·370	4	·657	1888·52	19·13	3	37·10
1889·34	29·493	3	·637	1889·48	28·18	2	37·17
1890·60	32·677	6½	·677	1890·37	36·71	8	36·71
1891·45	35·771	5½	·627	1891·36	45·35	1	36·36
1892·45	38·959	15½	·672	1892·40	54·20	9	36·20
1893·46	42·101	40	·672	1893·46	30 3·73	25	36·77
1894·45	7 33 45·245	23	·671	1894·47	84 30 13·04	25	37·06

For comparison with the last diagrams reference might be made to a paper by Mr. Burnham in the June number of *Astronomy and Astro-physics*, 1894, on the "Variable Proper Motion of *Procyon*," in which he discussed a series of measures of differences in declination between *Procyon* and two adjacent stars made during the years 1851–1890, by Otto Struve, and published in vol. x. of the Pulkova observations.

It does not seem probable that any further discussion of this series of observations, either of *Sirius* or *Procyon*, would lead to any results appreciably different from those deduced by Professor Auwers.

Note on the Measurement of Paper Prints of Stellar Photographs.
By Professor H. H. Turner, M.A., B.Sc.

1. The question of the accuracy attainable in measurements of a paper print is important, because the publication of a photograph in this form is a comparatively simple matter. The following brief notes of some experiments recently made at the University Observatory, Oxford, will, perhaps, serve to draw attention to the matter, though they are far from being a complete settlement of the question.

2. It is of course all-important that the original negative should have the *réseau* impressed upon it. If there is no *réseau* on the original negative, a glass copy can be made on which the *réseau* lines have been previously impressed, just as in preparing a plate for the telescope ; and the paper prints can then be made from this copy. As a digression I would remark that there are some advantages in *not* having the *réseau* on the original negative. It can be put on the positive copy in the laboratory much more conveniently *and correctly* than on the original negative ; that is to say, after examining the negative, and measuring one or two known stars, the *réseau* can be adjusted so that its lines are very nearly in the true directions for epoch 1900·0, and the centre at the proper point on the plate. Further, no stars less than the tenth mag. are obliterated on the original plate. Of course its lines would no longer be parallel to the fiducial edge of the plate. I am supposing this edge to be not used as fiducial.

3. The paper print having then a *réseau* on it, we proceed to measure the position of a star in any square of the *réseau*, for comparison with similar measures on the original negative. The print may be held between two pieces of plate glass, or wetted and squeezed to one of them. It must be viewed by reflected light, not transmitted light, as in the case of the original negative.

4. The following measures in the x coordinate were made of twelve stars on plate 703, and a platinotype print of it.

Plate 703, R.A., $10^h\ 48^m$. zone + 28°, exposed 1895 March 7.

Column 1 gives a number for reference.

Column 2 gives the approximate y coordinate expressed in *réseau* intervals from one corner.

Column 3 gives the diameter of the star-disc on the negative. The letter *e* denotes that the disc is much elongated, and a mean diameter is given.

Column 4, the x coordinate as measured on the original negative by the glass-scale micrometer described in *Monthly Notices*, lv. p. 102.

Column 5, the x coordinate as measured on the print with the screw micrometer, and the mean of several bisections (the object here being to determine systematic *not* accidental errors). The correction for "runs" was made on the assumption that the deformation was uniform over the square under examination.

Column 6 gives the differences, only one of which is as large as ·003 or 0″·9.

TABLE I.

(The results are all expressed in *réseau* intervals.)

Star.	y. (Approx.)	Diam.	Coordinate x. Negative.	Print.	P—N.
1	0·3	0·030	8·695	8·696	+·001
2	0·6	·030	9·621	9·621	0
3	0·6	·030	12·082	12·081	— 1
4	1·2	·038*e*	4·541	4·538	— 3
5	1·5	·012	9·083	9·082	— 1
6	1·8	·010	9·060	9·061	+ 1
7	1·7	·020	20·896	20·897	+ 1
8	1·2	·028	22·533	22·533	0
9	4·2	·023	22·836	22·835	— 1
10	21·2	·017	22·318	22·319	+ 1
11	23·1	·018*e*	21·741	21·740	— 1
12	20·8	·020	4·632	4·634	+ 2

Measurer of negative, Miss Turner; measurer of print, Mr. Bellamy.

These measures are all near the edge of the plate, where it was expected to find the deformation greatest.

5. The following measures on the same print were made by Professor Turner nearer the middle of the plate, with the glass-scale micrometer in general use for measuring plates. The

measures of the negative in columns (2) and (6) are, as before, those recorded by Miss Turner or Mr. Bennett in the ordinary course of measuring this plate last March. The measures in columns (3) and (7) were repeated specially by Mr. Bellamy. The mean of the two is taken for comparison with those on the print in columns (5) and (9).

TABLE II.

(Results expressed in *réseau* intervals as before.)

Diam. (Negative.)	*x* Coordinate. Negative.		Print.	P—N.	*y* Coordinate. Negative.		Print.	P—N.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
8*	4·418	·419	...	...	13·265	·265	...	...
22	5·635	·633	·635	+·001	·387	·387	·390	+·003
10	9·120	·119	·118	−·002	·440	·442	·437	−·004
11	9·702	·703	·698	−·005	·360	·362	·366	+·005
10	9·822	·822	·828	+·006	·595	·596	·592	−·004
13	9·940	·938	·941	+·002	·425	·425	·427	+·002
8*	10·454	·456	...	...	·507	·507	...	...
20	14·603	·603	·602	−·001	·378	·377	·380	+·002
9	19·589	·589	·589	·000	13·889	·888	·889	·000
10	3·554	·553	·556	+·002	14·178	·176	·177	·000
11	7·598	·596	·596	−·001	·165	·163	·164	·000
12	10·375	·374	·371	−·004	·314	·312	·312	−·001
14	21·376	·376	·373	−·003	14·540	·538	·540	+·001

The mean residual is $\pm$·002 or $\pm$ 0″·6. The measures on the print are not so good as those given in Table I. They are single measures with the glass-scale micrometer, instead of means of several careful bisections with a micrometer screw. And some difficulty was found in estimating the place of the broad and diffused images. The *réseau* lines on the plate are in fact not so good as they might be. The plate is, if anything, rather below the average in many respects, and the errors ought not generally to be so large as these.

6. Eleven stars on a pair of platinotype prints were measured with the glass-scale micrometer; the results are given in Table III.

* These two stars were not seen on the print.

TABLE III.

Plate 702. R.A. $10^h\ 30^m$. Zone $+28°$. Exposed 1895 March 7.

Two Platinotypes (positives) mounted on plate glass, with the back to the glass.

(1) Star.	(2)	(3)	(4)	(5)	(6)	(7)
	x Coordinate.			*y Coordinate*		
	A.	A. (repeated.)	B.	A.	A. (repeated.)	B.
1	11·079	11·085	11·083	2·596	2·587	2·592
2	11·591	11·591	11·595	3·271	3·270	3·281
3	11·723	11·724	11·726	7·210	7·210	7·217
4	11·952	11·951	11·950	9·763	9·762	9·764
5	11·925	11·925	11·925	18·444	18·344	18·339
6	12·378	12·373	12·372	9·874	9·870	9·874
7	12·556	12·556	12·551	11·616	11·618	11·616
8	12·214	12·214	12·215	15·775	15·774	15·776
9	12·589	12·592	12·595	18·627	18·627	18·624
10	12·767	12·771	12·774	20·182	20·182	20·181
11	12·138	12·139	12·140	20·268	20·270	20·267

These measures by Mr. Bellamy.

The measures given in columns (2) and (5) were made on November 6; the light was very bad.

Those in columns (3) and (6) were made on November 7, and are remeasurements of print A.

And those given in columns (4) and (7) were made on November 7, and from a different print, marked B.

The difference in *y* for star 2 is real; Mr. Bellamy went over the measures several times, and also examined all the other large differences.

The *réseau* lines are diffused on both these prints, owing to the lines on the negative being blurred. Another form of micrometer would, therefore, perhaps give better results, especially one where the setting on the *réseau* lines is made by a pair of wires, including a considerable portion of the line.

7. It seems to me, however, that these differences are, on the whole, very small. Briefly we can depend on paper prints (not enlargements, simply contact prints) to give us the places of

stars within 1″, possibly more accurately, and this is a fact well worth considering. I do not know how far the accuracy of paper prints treated in this way is known. It may be well to recall here some remarks made early in the history of the Chart by Dr. Gill, which perhaps may be taken to represent ideas on the subject generally. Dr. Gill gives no figures, and the only gauge of the accuracy he expects is afforded by the suggestion of a "rule and compass" method; it would appear to me that this does not give a sufficiently high estimate in the light of the above facts.

8. In the Procès-Verbaux of the meeting of the Comité Permanent in 1889 September, Annexe No. 1, are printed the notes presented to the Comité by Dr. Gill, and on p. 85, under the head Publication de la Carte, we read as follows :—

"Des copies de la carte sur verre entraîneraient des dépenses considérables; en outre, ce mode de publication est peu commode si l'on veut mesurer les plaques à l'aide d'une lunette, les images stellaires sur le négatif original étant trop petites pour être aperçues à l'œil nu. Le mode le plus simple consisterait, je le crois, à reproduire les plaques originales sur du papier, à l'aide de la photogravure ou de tout autre procédé analogue, en les agrandissant de trois diamètres, afin de rendre visibles les étoiles les plus faibles. . . . A l'aide du compas et de la règle on pourra déterminer sur ces copies à l'échelle de $3^{mm} = 1'$ la position d'une étoile quelconque du cliché, sinon avec une extrême, du moins avec une grande précision. Ce mode de publication ne serait pas très coûteux, la dimension des plaques serait peu gênante; de plus, on pourrait éliminer toute déformation du papier en ayant égard aux lignes du *réseau*."

9. The deformation of the paper has of course been allowed for in the above measures by the method of "runs," assuming it uniform throughout a square. It is a sensible quantity, and (as might be expected) different in the two coordinates. The stretching in the case of the above platinotype print was about ·003 in one direction and about ·013 in the other—a difference of 1 per cent. To test the regularity of the stretching across the paper, the widths of the spaces between consecutive *réseau* lines were measured across the plate, as below (Table IV.) with the screw micrometer. The results are expressed in *réseau* intervals as usual. The screw is not quite uniform, but the same part of it was used in measuring negative and print, so that the irregularity is eliminated from the differences N − P. The measures were made by Mr. Bellamy.

TABLE IV.

(1) Space.	(2) Interval on Negative.	(3) Interval on Print (1).	(4) Interval on Print (2).	(5) N−P₁.	(6) N−P₂.
0–1	0·9990	0·9961	...	+·0029	...
1–2	1·0007	0·9947	...	+·0060	...
2–3	0·9993	0·9974	...	+·0019	...
3–4	1·0004	0·9973	...	+·0031	...
4–5	1·0015	0·9984	...	+·0031	...
5–6	0·9981	0·9938	...	+·0043	...
6–7	1·0010	0·9986	...	+·0024	...
7–8	1·0012	0·9968	...	+·0044	...
8–9	0·9995	0·9953	...	+·0042	...
9–10	1·0010	0·9981	0·9960	+·0029	+·0040
10–11	0·9999	0·9966	0·9991	+·0033	+·0008
11–12	1·0000	0·9930	0·9902	+·0070	+·0098
12–13	1·0003	0·9989	0·9989	+·0014	+·0014
13–14	1·0015	0·9998	0·9981	+·0017	+·0034
14–15	1·0000	0·9936	0·9950	+·0064	+·0050
15–16	1·0003	0·9966	0·9977	+·0037	+·0026
16–17	1·0007	1·0020	1·0016	−·0013	−·0009
17–18	1·0007	0·9956	0·9970	+·0051	+·0037
18–19	1·0016	0·9970	...	+·0046	...
19–20	1·0005	0·9984	...	+·0021	...
20–21	0·9988	0·9943	...	+·0045	...
21–22	1·0006	0·9992	...	+·0014	...
22–23	1·0018	0·9977	...	+·0041	...
23–24	1·0008	0·9951	...	+·0057	...
24–25	1·0006	0·9930	...	+·0076	...
25–26	1·0023	0·9984	...	+·0039	...

The differences shown in column (5) are fairly regular with a few exceptions. To test the reality of the exceptions, the portion 9–18 was remeasured, as shown in columns (4) and (6). The differences in column (6) agree sufficiently well with those in column (5) to show that the abnormality of space 16–17, for instance, is real; but at the same time there are undoubtedly sensible accidental errors. Cp. the measures of space 10–11.

The existence of three consecutive spaces like 15–16, 16–17, and 17–18, whose widths are in the proportion 0·997, 1·001, 0·996, shows that the assumption of uniformity in the "runs" throughout one interval will not always give us accurate results, for we have no information as to where the change takes place.

10. The present note is not concerned with several matters of great importance; as, for instance, the possibility of securing all the stars on the print which are on the original plate. In the print above measured faint stars have certainly been lost. For the present I am only concerned with the value of such prints, in default of the original plate, for getting star-places with considerable accuracy. The experiments will be continued, and a fuller account of them given later. But if the question of the publication of the Chart is to be dealt with at the next meeting of the Permanent Committee, it is not too early to draw attention to the possibilities contained in paper prints, which have so many advantages over glass copies in the way of convenience.

Photograph of the Nebula H VI. 41 *and a new Nebula in Draco.*

By Isaac Roberts, D.Sc., F.R.S.

The photograph of the spiral nebula H VI. 41 *Draconis*, R.A. $17^h\ 33^m$, Decl. 75° 48′ north, and of the new elliptic nebula, R.A. $17^h\ 26^m\ 21^s$, Decl. 75° 8′·6 north (epoch 1860), was taken with the 20-inch reflector on 1895 September 11, with an exposure of the plate during 60 minutes, and the copy now presented is enlarged to the scale of 1 millimetre to 15 seconds of arc.

The nebula H VI. 41 is N.G.C. No. 6412, G.C. No. 4321, and is described by Sir J. Herschel as a globular cluster, considerably large, round, very gradually brighter in the middle, partially resolved.

The photograph shows it to be a spiral nebula, with a bright stellar nucleus, which appears to be elongated in *north following* and *south preceding* directions; and, involved in the spirals, are three or four nebulous star-like condensations. The general appearance of the nebula, and of the surrounding region of the sky, will best be appreciated on the photo-copy of the negative, now projected on the screen.

The elliptic nebula (supposed to be here recorded for the first time) is elongated in nearly *north* and *south* directions, with dense nebulous condensations in the interior and well-defined margins on the *preceding* and *following* sides, but the north and south ends are undefined, and shade gradually into invisibility. The length of the nebula does not exceed 70 seconds of arc, and the 9·2 magnitude star, D.M. No. 629, zone 75°, is about 30 seconds of arc *south preceding* it.

It will be observed on the photograph that the region of the sky surrounding these nebulæ is rather sparingly covered with stars, and that they are all fainter than 8th magnitude.

Photograph of the Cluster H *VIII. 76 and of a new Nebula in Cygnus.* By Isaac Roberts, D.Sc., F.R.S.

The photograph of the cluster H VIII. 76 R.A., $20^h\ 51^m{\cdot}5$, Decl. 46° 53′ north, and of a new nebula in *Cygnus* was taken with the 20-inch reflector on 1895 September 13, with an exposure of the plate during two hours. The copy now presented is enlarged to the scale of 1 millimetre to 24 seconds of arc.

The cluster is N.G.C. No. 6991, G.C. No. 4615, *h* 2091, and is described by Sir J. Herschel as large, poor, very little compressed.

The photograph shows that there is no cluster, in the ordinary, accepted use of the word, on the plate, but that there are densely crowded areas of stars in this as well as in many other regions of the sky; and I may here remark that Herschel's 8th class of clusters would be better designated as rich fields of stars. This designation, again, could be only relative, for an increase in the magnifying power of the observing instrument or of the photo-camera would separate the stars so that our ideas of a relationship between them would be entirely changed.

The new nebula (supposed to be here recorded for the first time) is in R.A. $20^h\ 50^m\ 56^s$, Decl. 46° 51′·9 north (epoch 1855), and it either involves, or else just touches, the star D.M. No. 3111 zone +46°. It is about 6½ minutes of arc in length from north to south, and 5 minutes of arc in breadth from *preceding* to *following*, irregular in outline and with many stars, both bright and faint, involved or in alignment with it. The nebulosity has no regular structure and is of a fleecy character, the margins gradually fading into invisibility.

The photograph shows that this nebula is surrounded by stars more numerous than is generally the case in the regions contiguous to nebulæ.

The Orbit of Σ 1379. By T. Lewis.

Observations of this binary are very scarce, although it has been known since 1827, when it was measured by W. Struve. This summer I had an opportunity of examining it with the 28-inch Greenwich refractor, and have deduced a provisional orbit principally to call attention to it. The position for 1900 is

R.A. $14^h\ 41^m\ 20^s$ N.P.D. 79° 55′ Mags. 7·7 and 8·5.

The residuals are in some cases large but are well within the discordances of the observations. The difficulty of the object since 1850 is sufficient to account for these variations, indeed the

law of equal areas is better satisfied than I had expected. The comparison of the apparent ellipse with observed places gives the best general idea.

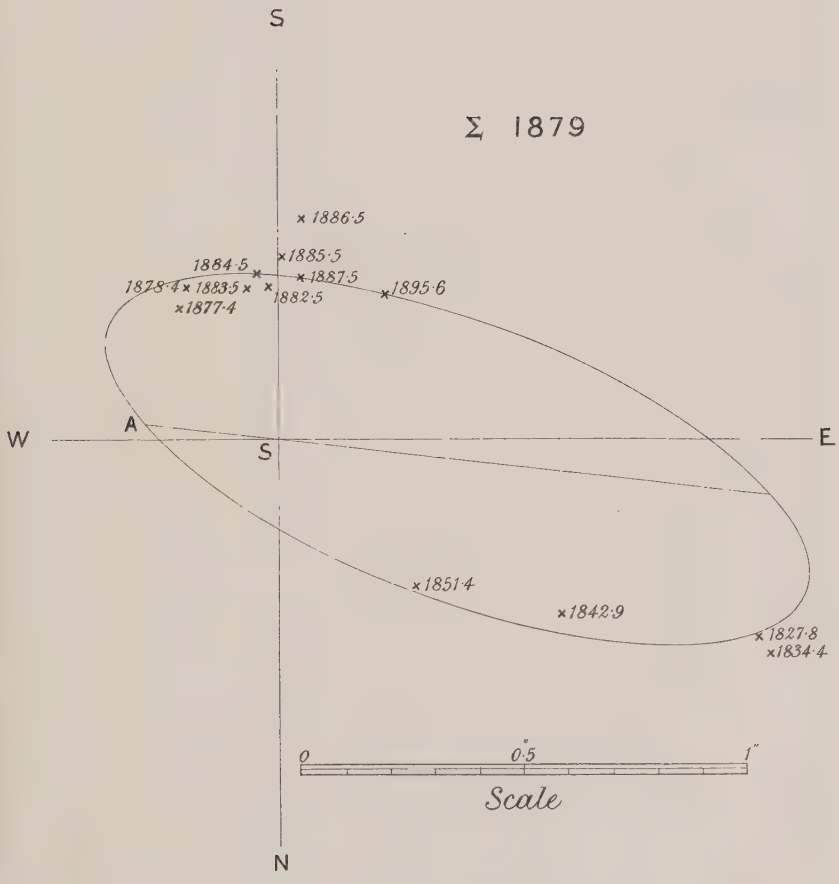
The elements are

τ	1865·0	Ω	64° 1′
ρ	146·9 years	γ	67 48
ϵ	·581	λ	222 47
a	0″·92	μ	−2°·45

Below is a comparison with all the observations I have been able to find, and a short ephemeris.

Date.	Position angle Observed.	Position angle Calculated.	Distance Observed.	Distance Calculated.	Observer.
	°	°	″	″	
1827·27	69·7	67·9	1·12	1·15	W. Struve
1828·32	65·8	67·3	1·22	1·13	W. Struve
1834·39	66·3	64·3	1·21	1·03	W. Struve
1842·42	59·2	59·0	0·80	0·85	Mädler
1843·42	57·2	58·2	0·69	0·82	Mädler
1851·41	43·5	47·9	0·45	0·55	Mädler
1877·40	30· ±	218·0	0·42	0·43	Burnham
1877·44	219·1	218·0	0·37	0·43	Schiaparelli
1877·46	222·9	217·9	0·34	0·43	Dembowski
1878·39	206·6	214·7	0·39	0·43	Dembowski
1878·44	217·1	214·6	0·42	0·43	Burnham
1882·50	183·5	198·9	0·35	0·39	Schiaparelli
1883·47	177·9	194·0	0·38	0·39	Schiaparelli
1883·55	209·4	193·9	0·31	0·39	Engelmann
1884·50	187·3	190·0	0·37	0·38	Schiaparelli
1885·48	179·5	185·4	0·41	0·37	Schiaparelli
1886·51	174·2	180·8	0·50	0·37	Schiaparelli
1887·44	173·1	175·8	0·38	0·37	Hall
1887·49	173·1	175·7	0·35	0·37	Schiaparelli
1895·44	144·6	140·5	0·40	0·41	Lewis
...	...	...	...	...	
1896·5	...	137·0	...	0·43	
1897·5	...	133·6	...	0·45	
1898·5	...	130·3	...	0·47	
1899·5	...	127·2	...	0·48	
1900·5	...	124·6	...	0·50	

1895 *November* 4.


S
Σ 1879
×1886·5
×1885·5
1884·5
×1887·5
1878·4 ×1883·5 ×
×1882·5
×1877·4
×1895·6
W
A
S
E
×1851·4
×1842·9
×1827·8
×1854·4
0
0"·5
1"
Scale
N

Observations of the Variable Star T Centauri.

By Lieut.-Col. E. E. Markwick.

This star proves to be an interesting variable on account of the large range in variation, $4\frac{1}{2}$ magnitudes, and its comparatively short period. My observations, in continuation of those on p. 247, vol. v. *Journal B. A. Assoc.*, are as follows. They were usually made with a binocular magnifying five times, supplemented by a $2\frac{3}{4}$-inch refractor, power 28. The comparison star, for the brighter stages, was L 5649, which is 23′ S of the var., and rated $7^{m}\cdot0$ in the *Uranometria Argentina*. The difference in brightness was estimated in steps, or tenths of a magnitude.

1894-	m		m		m		m
Dec. 29	7·1	May 14	8·0	June 3	6·0	June 23	6 5
1895.							
Jan. 2	7·2	15	7·4	4	6 0	24	6·6
6	7·5	16	7·4	5	5 to 5½	26	6 65
29	9	17	7·3	6	5 5	27	6·7
Apr. 19	9·25	19	7·3	8	5 3	29	6 8
20	9·6	20	7·25	10	5·5	30	6·7
21	9·75	21	7·2	11	6·25	July 1	6·8
22	9·75	22	7·2	12	6·2	2	6·8
25	10	25	7·05	13	6·3	3	6·8
26	10	26	7·0	14	6·2	8	7·1
May 3	9·7	28	6·8	16	6·0	11	7·5
5	9·6	30	6·25	17	6·25	12	7·75
6	9·3	31	6·25	19	6·27	13	7·75
7	9·22	June 1	6·25	20	6·3	14	7·75
8	8*	2	6·0	21	6·4	17	8·5
						21	9·5

I attach a drawing showing the light-curve in 1894 and 1895 as deduced from the previous and the 1894 observations.

Neither of these, it will be observed, gives a complete cycle of variation, and it is somewhat difficult to arrive at the period. In the above-quoted paper seventy-three days was thought to be something near the truth, and from the additional observations now obtained it would appear that this is so.

The star was observed $6^{m}\cdot25$ on 1894 May 26, but there was a gap in the observations of seventeen days prior to this, the next preceding observation being 8^{m} on May 9. Now an in-

* Very bright moonlight, making observation difficult.

spection of the 1895 curve shows the maximum to have occurred eight days prior to the secondary maximum indicated by the "hump" on the curve for June 16. Accordingly, taking eight days from 1894 June 2, the date of the secondary maximum or that year, we get 1894 May 25 as a fairly probable date of maximum. This is corroborated by the photographic magnitudes of the star communicated by Professor E. C. Pickering to *Astr. Nachr.* No. 3269, col. 72, which show it to be actually slightly rising on 1894 May 24. The last plate taken on that day shows it as brighter than on any other occasion, although twenty-three plates were taken on various dates in the years 1889–1894.

The maximum in 1895 may pretty safely be allocated from my observations to June 8.

From 1894 May 25 to 1895 June 8 is 379 days. Supposing five periods to have elapsed in the interim, we get (i) 75·8 days as mean period.

From the photographic magnitudes the star appears to have been at or near a minimum on 1893 July 27. My observations show a minimum pretty clearly on 1895 April 26. From the former to the latter is 638 days. Taking nine periods to have elapsed, this gives (ii) 70·9 days as mean period.

We now get from the mean of (i) and (ii) as approximate elements of maximum, epoch 1894 May 25 (Julian, 241, 2974) + 73·35 *d*. E. Variation, maximum 5·3 − 6·25 to minimum 10·0. Interval from minimum to next succeeding maximum forty-three days.

This will suit the observations of December 1894 and January 1895, supposing a faint maximum to have occurred about them.

With the above elements the photographic magnitudes of Pickering have been compared by plotting them on a typical light-curve. Those of 1894 agree fairly well. Those of 1893 do not, as they would appear to show the star's light to be falling when calculation makes it rising. In 1892 only one plate was taken. In 1891 and 1889 it is impossible to deduce any regular change. In 1890 the slight variation shown is fairly in agreement.

On the whole, seeing the short time the star has been under observation since its discovery, I can only regard these elements as provisional.

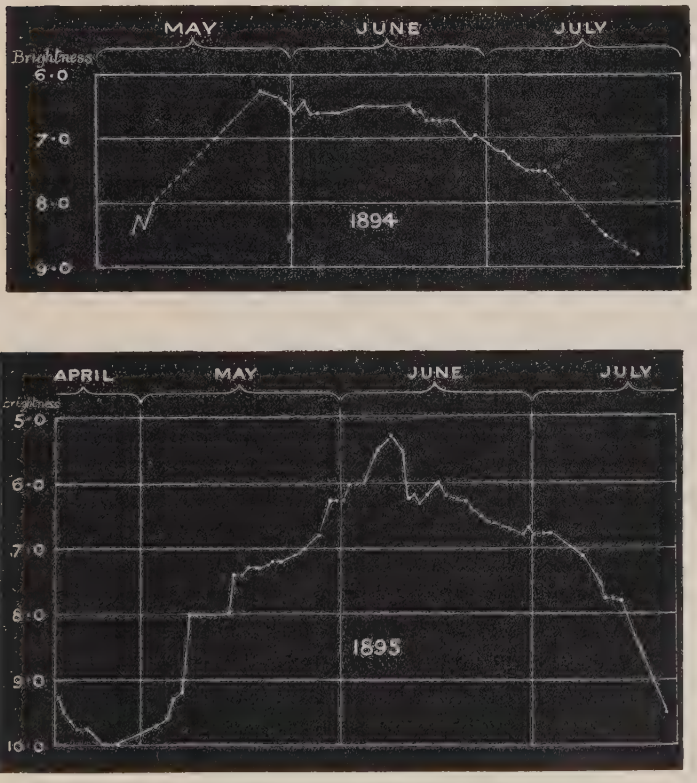
As noted in my paper in the *B. A. A. Journal*, it was observed by Lacaille (7^m) between June 16 and June 26, 1752. Say (*a*) June 21 as mean. It is No. 5738 of Yarnall, and rated $6^m{\cdot}0$. Observed at Washington in R.A. (*b*), 1862·80, and in declination (*c*), 1870·40. Supposing the star was at maximum on these three occasions, we have from

a to *b*	= 40,296 days
b to *c*	= 2,776 ,,
b to 1894 May 25	= 11,541 ,,

With a period of 73·35 days, the residuals are respectively 27 days, 11 days, and 25 days.

However, it is quite possible that there may be inequalities in the period which would throw out the maximum considerably when calculated for a lengthy period of years. Again, the star evidently varies very slowly about the time of maximum, so that the three ancient dates mentioned are merely approximate, so far as they are regarded as representing the maximum. These observations may therefore possibly be in accordance with the period named, supposing there are inequalities in it.

It is probable the brightness varies at different maxmia.



Light variations of *T Centauri.*

In the latitude of Gibraltar one can only observe it in ordinary working evening hours for a comparatively short time each year. A regular series of observations made in the southern hemisphere over a year or two would very soon throw much light

on the variation, and it is much to be desired that someone in the Cape or Australia will take it up.

The position of the star for 1906 is R.A. $13^h\ 36^m\ 2^s$, Decl. $-33°\ 5'{\cdot}5$; No. 4896 in Chandler's List of New Variables supplementary to Cat. in No. 300 of the *Ast. Journal*. It is also No. 252 of *Centaurus* in the *Uran. Arg.*

On 1895 May 14 it was slightly orange in tint; May 15, in $2\frac{3}{4}$-inch refractor, various powers, 28 to 200, noted as slightly yellow. Generally speaking, towards maximum it appears yellowish with tinge of orange; and after maximum I think the orange tint is slightly more pronounced.

It may possibly be of the type of *S Vulpeculæ* or *R Sagittæ*, although the range of variation is greater.

Gibraltar: 1895 *October.*

Results of Filar Micrometer Comparisons of Saturn with 96 *Virginis, and of Ceres with Neighbouring Stars.* By John Tebbutt.

The accompanying table contains the results of comparisons with the filar-micrometer on the 8-inch equatorial. In the comparisons of *Saturn* the first and north, and second and south, limbs were observed alternately, and the differences of R.A. and N.P.D. for both planets have been corrected for refraction, and a small error in the perpendicularity of the micrometer threads. The semidiameter of *Saturn* and the parallaxes of both planets have been taken from the *Nautical Almanac*, and the resulting geocentric places have finally been compared with the ephemerides on page 262 of the almanac and page 4 of its appendix. The errors for *Saturn* differ but little from those determined by me in May last from comparisons with *κ Virginis* and already forwarded to the Society.

Saturn.

Date.	Windsor Mean Time.	Planet's Centre – Star. R.A.	Planet's Centre – Star. N.P.D.	No. of Comps.	Star Reductions R.A.	Star Reductions N.P.D.	Parallax Corrections. R.A.	Parallax Corrections. N.P.D.	Geocentric Apparent Place of Planet's Centre. R.A.	Geocentric Apparent Place of Planet's Centre. N.P.D.	Comp. Star.	Error of *Nautical Almanac* R.A.	Error of *Nautical Almanac* N.P.D.
1895.	h m s	m s	′ ″		s	″	s	′	h m s	° ′ ″		s	″
Aug. 4	7 10 28	−3 22·65	− 7 51·8	20	+1·96	+14·6	+0·03	+0·4	14 0 4·22	99 42 36·2	1	+0·14	+1·7
8	8 3 53	−2 35·72	− 2 33·3	11	+1·92	+14·4	+0·04	+0·4	14 0 51·12	99 47 54·5	1	+0·14	+1·9
9	7 33 39	−2 23·47	− 1 12·4	20	+1·91	+14·4	+0·03	+0·4	14 1 3·35	99 49 15·4	1	+0·09	+2·2
10	7 42 14	−2 10·69	+ 0 13·0	20	+1·90	+14·3	+0·04	+0·4	14 1 16·13	99 50 40·7	1	+0·14	+2·0
11	7 22 19	−1 57·75	+ 1 38·1	20	+1·88	+14·2	+0·03	+0·4	14 1 29·04	99 52 5·7	1	+0·14	+2·0
12	7 32 53	−1 44·28	+ 3 7·4	18	+1·87	+14·2	+0·03	+0·4	14 1 42·50	99 53 35·0	1	+0·18	+1·0

Ceres.

June 28	10 6 30	+1 16·07	− 4 44·9	10	+3·71	+ 7·3	−0·13	+0·7	18 15 5·27	117 22 26·1	2	−1·80	−5·8
29	8 41 47	+0 20·96	− 1 28·5	6	+3·72	+ 7·3	−0·22	+1·1	18 14 10·08	117 25 42·9	2	−1·91	−6·5
30	9 39 14	−0 40·23	+ 2 4·9	10	+3·73	+ 7·3	−0·15	+0·7	18 13 8·97	117 29 15·9	2	−1·66	−7·0
30	9 39 14	−0 2·08	...	10	+3·74	...	−0·15	...	18 13 8·95	...	3	−1·64	...
July 1	8 44 55	−1 36·03	+ 5 17·4	10	+3·75	+ 7·4	−0·20	+1·0	18 12 13·14	117 32 28·8	2	−1·88	−7·3
1	8 44 55	−0 57·97	...	10	+3·75	...	−0·20	...	18 12 13·02	...	3	−1·76	...
2	8 21 28	−2 33·07	+ 8 30·6	8	+3·76	+ 7·4	−0·22	+1·1	18 11 16·09	117 35 42·1	2	−1·79	−7·7
2	8 21 28	−1 54·88	...	8	+3·76	...	−0·22	...	18 11 16·10	...	3	−1·80	...
4	8 51 22	−1 4·51	− 2 55·3	9	+3·78	+ 7·7	−0·18	+0·8	18 9 20·22	117 42 2·6	4	−1·62	−5·0
5	9 6 46	−2 1·41	+ 0 10·0	9	+3·79	+ 7·8	−0·16	+0·7	18 8 23·35	117 45 7·9	4	−1·84	−5·2
7	8 12 36	−1 23·55	−12 24·5	9	+3·81	+ 8·3	−0·20	+1·0	18 6 34·27	117 50 53·4	5	−1·83	−4·0
8	8 45 56	+0 27·88	− 9 30·3	10	+3·82	+ 8·4	−0·16	+0·8	18 5 38·65	117 53 47·5	5	−2·03	−4·0

Date.	Windsor Mean Time.	Planet's Centre—Star. R.A.	N.P.D.	No. of Comps.	Star Reductions R.A.	N.P.D.	Parallax Corrections. R.A.	N.P.D.	Geocentric Apparent Place of Planet's Centre. R.A.	N.P.D.	Comp. Star.	Error of *Nautical Almanac.* R.A.	N.P.D.
1895.	h m s	m s	′ ″		s	″	s	″	h m s	° ′ ″		s	″
July. 9	8 49 41	−0 26·37	− 6 44·7	10	+3·82	+ 8·4	−0·16	+0·7	18 4 44·40	117 56 33·0	5	−1·71	−3·3
12	7 38 8	−3 0·08	+ 0 59·7	10	+3·84	+ 8·5	−0·21	+1·0	18 2 10·66	118 4 17·8	5	−1·74	−4·6
15	7 17 2	−0 27·39	−11 1·6	10	+3·85	+ 9·1	−0·21	+1·0	17 59 43·60	118 11 28·5	6	−1·79	−4·0
15	7 17 2	−1 46·08	...	10	+3·86	...	−0·21	...	17 59 43·51	...	7	−1·70	...
16	8 3 16	−1 16·06	− 8 39·1	10	+3·85	+ 9·2	−0·17	+0·7	17 58 54·97	118 13 50·8	6	−1·80	−5·8
16	8 3 16	−2 34·66	...	10	+3·86	...	−0·17	...	17 58 54·97	...	7	−1·80	...
17	8 32 4	−2 3·03	− 6 24·8	10	+3·85	+ 9·2	−0·13	+0·6	17 58 8·04	118 16 5·0	6	−1·74	−5·3
17	8 32 4	−3 21·65	...	10	+3·86	...	−0·13	...	17 58 8·02	...	7	−1·72	...

Adopted Mean Places of the Comparison Stars for 1895·0.

Star.	R.A.	N.P.D.	Authorities.
	h m s	° ′ ″	
1	14 3 24·88	99 50 13·0	Greenwich Catalogues for 1864, 1872, 1880, and Radcliffe Catalogues for 1860, 1890.
2	18 13 45·62	117 27 3·0	Arg. Oeltzen 18,047, Arg. Gen. Cat. 24,978.
3	18 13 7·44	117 32 52·6	Arg. Oeltzen 18,028.
4	18 10 21·13	117 44 49·4	Arg. Gen. Cat. 24,884, Stone 9,960.
5	18 5 7·11	118 3 8·6	Arg. Oeltzen 17,772, Arg. Gen. Cat. 24,748.
6	18 0 7·35	118 22 20·0	Arg. Oeltzen 17,611, Arg. Gen. Cat. 24,623, Stone 9,860.
7	18 1 25·94	118 28 5·0	Arg. Oeltzen 17,653, Arg. Gen. Cat. 24,649, Stone 9,869.

Private Observatory, Windsor, N.S. Wales:
1895 September 13.

Observations of Encke's Comet made with the 15-inch Equatorial of the National Mexican Observatory, Tacubaya.

By Felipe Valle.

(Communicated by the Secretaries.)

Long. W. $6^h\ 36^m\ 46^s{\cdot}53$. Lat. N. $19°\ 24'\ 17''{\cdot}5$.

Date.	Tacubaya Mean Time.	Comet−Star. $\Delta\alpha$	Comet−Star. $\Delta\delta$	No. of Comps.	Observer.	Comet App. R.A.	Log. $p\times\Delta$ of Parallactic Factor.	Comet App. decl.	Log. $p\times\Delta$ of Parallactic Factor.	Red. to App. Place.	No. of Star.
1894.	h m s	m s	′ ″			h m s		° ′ ″		s ″	
Dec. 28	7 40 28·6	+3 48·13	+0 01″·32	6–6	F. V.	22 14 49·03	+9·6790	+3 20 29″·9	+0·4236	+2·31 +14″·29	1
29	7 34 18·7	−0 33·17	+3 07·08	10–10	,,	22 14 33·68	+9·6767	+3 22 08·8	+0·4246	+2·35 +14·75	2
31	7 39 52·9	+0 42·76	−1 27·90	9–9	,,	22 14 01·59	+9·6918	+3 06 17·4	+0·4329	+2·31 +14·12	3
1895.											
Jan. 4	7 31 55·0	+0 54·48	−0 45·50	12–12	,,	22 12 27·64	+9·7005	+2 29 56·9	+0·4410	−0·75 − 5·75	4
12	7 10 34·9	−1 18·65	−0 05·36	7–7	,,	22 06 03·61	+9·7138	+0 39 55·3	+0·4601	−0·78 − 5·66	5
14	7 25 16·9	−0 13·95	+0 55·01	4–4	,,	22 03 09·83	+9·7299	−0 02 08·2	+0·4658	−0·79 − 6·12	6
15	7 03 07·2	−1 43·26	+2 22·11	7–7	,,	22 01 33·63	+9·7201	−0 24 52·4	+0·4686	−0·78 − 6·29	7
17	6 53 15·7	−1 33·01	+1 25·48	7–7	,,	21 57 32·85	+9·7205	−1 19 14·0	+0·4746	−0·79 − 6·76	8
18	7 11 35·7	+1 11·63	+1 53·22	4–4	,,	21 55 08·29	+9·7359	−1 51 11·8	+0·4710	−0·80 − 7·10	9
19	6 53 43·4	−0 22·79	−5 34·74	11–11	,,	21 52 30·52	+9·7297	−2 25 16·0	+0·4789	−0·80 − 7·27	10
21	6 51 36·0	−0 37·75	−5 21·52	8–8	,,	21 46 15·25	+9·7358	−3 45 28·9	+0·4465	−0·78 − 7·81	11
22	6 45 29·4	−4 38·20	−2 01·26	1–1	,,	21 42 37·38	+9·7370	−4 31 17·1	+0·4843	−0·79 − 7·98	12

Comparison Stars

No. of Star.	α 1894·0–1895·0. h m s	δ 1894·0–1895·0 ° ″	Authority.	Date. 1894.	Observed Δα. s	Calculated Δδ. ″	Ephemerides.
1	22 10 58·59	+3 30 14·3	Schjellerup ½ (9096 + 9097)	Dec. 28	+ 1·48	− 0·1	Backlund, Bull. Acad. St. Pétersbourg, I.
2	(2a − 4 00·63)	(2a + 2 25·21)	Anon. Ref. to 2a (10·0)	29	...	...	,,
2a	22 19 05·13	+3 16 22·0	B. D. + 3°·4701 (8·5)				
3	22 13 16·52	+3 07 31·3	B. D. + 2°·4490 (9·0)	31	...	...	,,
4	22 11 33·91	+2 30 48·1	(9·0) B. D. + 2°·4485	1895. Jan. 4	+ 1·33	+ 2·17	,,
5	22 07 23·04	+0 40 06·3	(8·3) B. D. + 2°·4836	12	...	...	,,
6	22 03 24·57	−0 02 57·1	(9·3) B. D. + 0°·4313	14	...	...	,,
7	22 03 17·67	−0 27 08·2	(8·5) 9033 Schjellerup	15	+ 5·37	+ 31·1	,,
8	(8a − 16·68)	(8a + 4 17·64)	B. D. − 1°·4242. Ref. to 8a	...	...	...	,,
8a	21 59 23·33	−1 24 50·4	(6·5) 5936 Radcliffe 1890	17	+ 6·84	+ 52·2	,,
9	21 53 57·46	−1 52 57·9	(8·9) 5919 Radcliffe 1890	18	+ 6·86	+ 45·5	,,
10	21 52 54·11	−2 19 34·0	(8·4) B. D. − 2°·5668	19	+ 7·25	+ 61·5	,,
11	21 46 53·78	−3 39 59·6	(6·0) 5894 Radcliffe 1890	21	+ 7·86	+ 61·6	,,
12	21 47 16·37	−4 29 07·9	(7·0) 5895 Radcliffe 1890	22	+ 8·01	+ 67·5	,,

Observations of Minor Planets made with the 15-inch Equatorial of the National Mexican Observatory, Tacubaya.

By Felipe Valle.

(*Communicated by the Secretaries.*)

Long. W. $6^h\ 36^m\ 46^s.53$. Lat. N. $19°\ 24'\ 17''.5$.

Date.	Tacubaya Mean Time.	Planet $\Delta\alpha$.	Star $\Delta\delta$.	No. of Comps.	Observer.	Planet App. R.A.	Log $p \times \Delta$ of Parallactic Factor.	Planet App. Decl.	Log $p \times \Delta$ of Parallactic Factor.	Red. to App. Place.	No. of Star.
						(176) *Idunna.*					
1894.	h m s	m s	′ ″			h m s		° ′ ″		s ″	
Oct. 3	11 32 58	+1 41·11	−1 5·84	5–5	F. V.	...	+7·971	...	+0·131	+3·44 +23·90	1*a*, 1
6	9 52 57	−1 17·21	−1 37·58	4–4	,,	0 19 7·32	+9·302	+9 48 51·3	+0·191	+3·46 +24·15	2
8	11 20 3	−0 38·34	−0 26·80	6–6	,,	0 17 55·23	+8·522	+9 20 5·3	+0·185	+3·46 +24·15	3*a*, 3*b*
9	10 6 56	−0 58·34	+4 16·35	6–6	,,	0 17 22·80	9·129*n*	+9 6 52·4	+0·200	+3·48 +24·32	4
10	8 53 5	+2 1·00	−3 10·41	5–5	,,	0 16 50·71	9·465*n*	+8 53 36·7	+0·251	+3·47 +24·24	5
11	8 47 29	−1 37·39	−6 22·32	6–6	,,	0 16 17·94	9·419*n*	+8 39 43·4	+0·259	+3·48 +24·35	6
						(190) *Ismene.*					
Nov. 5	10 9 17	+1 0·93	+0 55·44	6–6	F. V.	2 18 23·57	9·213*n*	+8 5 4·8	+0·248	+3·82 +25·25	7

Date.	Tacubaya Mean Time.	Planet $\Delta\alpha$.	Star $\Delta\delta$.	No. of Comps.	Observer.	Planet App. R.A.	Log $p \times \Delta$ of Parallactic Factor.	Planet App. Decl.	Log $p \times \Delta$ of Parallactic Factor.	Red. to App. Place.	No. of Star.
						(28) *Bellona.*					
1894.	h m s	m s	′ ″			h m s		° ′ ″		s ″	
Dec. 4	8 20 20	+0 51·35	−5 32·90	11–11	P. S.	5 21 30·67	9·694*n*	+8 49 4·3	+0·357	+4·39 +14·04	8
17	8 0 51	−0 28·79	+0 37·72	12–12	,,	5 9 30·79	9·638*n*	+8 57 18·8	+0·314	+4·55 +13·65	9
27	9 11 8	−1 2·07	+0 24·85	7–7	F. V.	5 0 52·31	9·302*n*	+9 21 15·9	+0·208	+4·62 +13·69	10
28	10 3 26	−1 50·54	+3 55·44	5–5	,,	5 0 3·86	8·807*n*	+9 24 35·6	+0·183	+4·62 +13·61	10
29	9 37 17	+2 30·36	−2 4·59	5–5	,,	4 59 17·91	9·066*n*	...	+0·187	+4·62 +14·03	11
						(76) *Freia.*					
Dec. 28	9 4 40	+1 5·91	+1 43·66	6–6	F. V.	5 7 7·05	9·366*n*	+20 28 3·2	+8·703	+4·95 +14·62	12
29	8 47 40	+0 24·51	+0 44·93	8–8	,,	5 6 25·66	9·418*n*	+20 27 4·4	+9·072	+4·96 +14·63	12
30	8 41 46	+0 57·67	+0 31·62	5–5	,,	5 3 48·93	9·366*n*	+20 23 28·1	+8·786	+4·96 +14·95	13
						(164) *Eva.*					
Dec. 31	10 1 2	+1 2·93	−0 36·05	7–7	F. V.	5 58 46·07	9·346*n*	+35 46 10·4	0·352*n*	+5·82 + 9·72	14
1895. Jan. 2	9 37 3	−1 1·89	−1 29·48	7–7	,,	5 56 5·61	9·415*n*	+36 1 55·1	0·340*n*	+1·81 + 9·89	15
3	9 6 15	+0 24·73	−2 31·27	7–7	,,	5 54 48·99	9·519*n*	+36 9 6·7	0·293*n*	+1·81 + 9·98	16
4	10 56 11	+1 36·82	+0 36·85	4–4	,,	5 53 26·02	+7·486	+36 16 49·9	0·413*n*	+1·81 +10·22	17

Note.—The observations marked "P. S." were made by Señor Pedro Sanchez.

Comparison Stars.

No. of Star.	α 1894·0.	δ 1894·0.	Authority.	Date.	Observed—Calculated $\Delta\alpha$.	$\Delta\delta$.	Ephem.
			(176) *Idunna.*				
	h m s	° ′ ″			s	″	
1*a*	...	...	B. D. +10°·39 (9·3)		...	...	Ast. Nach.
1	(1*a*+1 31·64)	(1*a*−3 50·02)	Anon. (10·5). Ref. to 1*a*		...	...	
2	0 20 21·07	+ 9 50 4·8	(8·6) A. G. Z. Leipzig	Oct. 6	+ 0·29	+ 6·1	,,
3*a*	0 15 1·28	+ 9 20 55·85	(8·7) ,, ,,		...	...	,,
3*b*	0 18 30·11	+ 9 20 7·9	(10·0) = 3*a* + 3^m 28^s·83 −0′ 47″·94	8	+ 0·50	+ 3·6	,,
4	0 18 17·66	+ 9 2 11·7	(8·7) A. G. Z. Leipzig	9	+ 0·45	+ 5·6	,,
5	0 14 46·24	+ 8 56 22·9	(8·8) A. G. Z. Leipzig	10	+ 0·22	+ 4·3	,,
6	0 17 51·85	+ 8 45 41·4	(8·7) A. G. Z. Leipzig	11	+ 0·38	+ 4·0	...
			(190) *Ismene.*				
7	2 17 18·82	+ 8 3 44·1	B. D. (8·2) + 7°·375 = ξ^2 *Ceti* { −5^m 12^s·55 / +4′ 39″·04 }	Nov. 5	+ 8·57	+29·1	B. A. Jahrb.
			28 *Bellona.*				
8	5 20 34·93	+ 8 54 23·2	(8·4) Glasgow 1326	Dec. 4	+ 0·01	− 2·7	R. Luther.
9	5 9 55·03	+ 8 56 27·4	(8·3) Schjellerup 1693	17	− 0·42	+ 5·2	,,
10	5 1 49·78	+ 9 20 26·5	(6·5) Cincinnati $_{12}$ − 313	27	+ 0·32	− 1·0	,,
10	5 1 49·78	+ 9 20 26·5	,, ,, ,,	28	+ 0·50	+ 4·2	,,
11	4 56 42·93	...	(8·5) B. D. +9°·711	29	− 1·40	...	,,

No. of Star.	α 1894·0.	δ 1894·0.	Authority.	Date.	Observed − Calculated Δα.	Δδ.	Ephem.
			(76) *Freia.*				
	h m s	° ′ ″			s	″	
12	5 5 56·19	+20 26 4·9	B. D. +20°·900 (Merid. Circ., Tacubaya)	Dec. 28	+30·16	+28·6	B. A. Jahrb., 1896.
12	5 5 56·19	+20 26 4·9	,, ,,	29	+30·18	+28·4	,,
13	(13*a* −9s·45)	(13*a* +3′ 28″·19)	B. D. +20°·889. Ref. to 13*a*		...	...	
13*a*	5 2 55·75	+20 19 13·4	B. D. +20°·890 (Tacubaya meridian)	30	+30·17	+28·1	,,
			(164) *Eva.*				
14	5 57 37·32	+35 46 36·7	B. D. +35°·1328	Dec. 31	...	..	B. A. Jahrb.
	1895·0.	1895·0.		1895.			
15	5 57 5·88	+36 3 14·7	B. D. +36°·1344 = 15*a* { −3m 45s·10 / −1′ 28″·42 }	Jan. 2	+1·96	+1·93	,,
15*a*	6 0 50·98	+36 4 45·0	Yarnall −2579		...	...	,,
16	5 54 22·45	+36 11 28·0	Anon. = 16*a* { −5m 57s·66 / −5′ 38″·50 }	3	+2·06	+15·9	,,
16*a*	6 0 20·11	+36 17 6 5	...		...	...	
17	5 51 47·39	+36 16 2·8	B. D. +36° 1317. Ref. to 15*a* & 16*a*	4	+2·07	+18·1	,,

Errata.

Monthly Notices, vol. lv. page 290, last line but three :

for G = 22^h 32^m *read* G = 20^h 32^m.

List of Presents, &c. 1894–95.

Page 276, 5th title from bottom :

for presented by the author *read* presented by Mr. M. C. Sharp.

Memoirs R.A.S. vol. li. page 90, last line :

for $l = a \sec \theta_2 = 2\lambda \sin \theta_2$ *read* $l = a \sec \theta_2$ simply (*i.e. dele* $= 2\lambda \sin \theta_2$).

Page 91 :

dele lines 1 and 2.